AN

INTRODUCTION

TO

MINERALOGY:

COMPRISING THE

NATURAL HISTORY AND CHARACTERS OF MINERALS;

AND A DESCRIPTION OF ROCKS,

BOTH SIMPLE AND AGGREGATED;

WITH

A NEW TABULAR ARRANGEMENT OF EARTHY MINERALS,

ON A PLAN DESIGNED TO FACILITATE THE KNOWLEDGE
OF THAT CLASS OF SUBSTANCES.

To which is prefixed:

A SERIES OF CONVERSATIONS

EXPLAINING THE PRINCIPLES OF THE SCIENCE,

AND THE

ELEMENTS OF CRYSTALLOGRAPHY.

By ROBERT BAKEWELL,

AUTHOR OF "AN INTRODUCTION TO GEOLOGY."

WITH PLATES.

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PREFACE.

No circumstance more strikingly distinguishes civilised from savage nations, than the application of the productions of the mineral kingdom to the service of man, in the rudest stages of society the use of mineral substances being scarcely known. From the mineral kingdom, man first received the arms which secured to him dominion over the beasts of the forest, and enabled him to resist the fury of the elements, or render them in a great degree subservient to his will. Nearly all the useful implements and ornamental decorations of the most polished nations of ancient or modern times, have been derived from the mineral kingdom; and yet it is only within the short period of the last half century, that mineralogy has been regularly cultivated as a science, or engaged the attention of any classes of society, except the working miners. This is the more surprising when we recollect, that gold, silver, and various precious stones, have been the objects of insatiable cupidity and research for many thousand years. Notwithstanding our valuable mines of tin, copper, lead, iron, rock-salt, and coal, so little attention was paid to mineralogy as a science in this country, that Mr. Kirwan's "Elements," published in 1784 and 1795, was the first regular treatise on the subject in our language, entitled to notice. Mr. Kirwan may be regarded as the Father of British Mineralogy, and considering the period in which his work was written, it possessed a very high degree of merit.*

On the continent of Europe, there are at present two schools of mineralogy, the German and the French; the founder of the former was the late distinguished professor of Freyberg, Mr. Werner, whose method of instruction has been followed in this country by Mr. Jameson, and fully and ably developed in his

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* Mr. Kirwan, in a letter I received from him in 1810, informed me, that the third edition of his work, which appeared that year, was published against his approbation, and that he had declined for some time previously the further cultivation of the science.

"System of Mineralogy," in 3 vols. 8vo.; and in his treatise "On the External Characters of Minerals."

The system of Haüy was published in 4 vols. in 1801, entitled "*Traité de Minéralogie;*" and another work, which may be regarded as a supplement, was published in 1809, entitled "*Tableau Comparatif, des resultats de la Crystallographie, et de l'Analyse Chimique relativement a la Classification des Minéraux.*" The principles on which the two systems are founded are explained in the first part of the present work; it may here be sufficient to observe, that the peculiar merit claimed for Werner by his disciples, is the invention of a technical language, to convey a correct idea of all the external characters and appearances of minerals, such as the colour, lustre, form, fracture, &c.; and in the description of minerals, according to the Wernerian method, all the external characters, whether essential or accidental, are most minutely detailed.

In the system of Haüy, the crystalline structure and chemical composition of minerals, are chiefly regarded, and only the more important external characters are noticed.

Before the time of Werner, it is said mineralogists of different countries had no definite terms by which their descriptions of minerals could be made intelligible to each other; but it may fairly be doubted whether the vagueness complained of, in the descriptive language of former mineralogists, did not proceed rather from defective or inaccurate observations, than from defective terms. Werner certainly introduced a greater degree of accuracy, in the examination of minerals; this is merit of a higher kind than the invention of new terms, many of which are harsh and obscure. In the German method of describing minerals, the meaning is sometimes almost buried under a heap of terms, which, to speak in the language of that school, are "particularly difficultly intelligible;" added to this, a mineral is often divided into so many species, subspecies, varieties, and kinds, according to the varieties of colour, or other accidental qualities, that the learner finds the subject rendered obscure, by the multiplicity and minuteness of the illustrations. The descriptions may be compared to a window in a Gothic cathedral, where so much care has been taken to make the glass-work firm, by compartments and subdivisions of lead and stone, that the use of the window for the admission of light seems to have been forgotten.

It cannot be denied, that it is difficult to describe inorganic substances like minerals, in language that shall appear simple and intelligible, and the first principles of mineralogy have so little in common with the other sciences or the daily concerns of life, that learners generally find the study irksome at first.

On this account, I have adopted the form of dialogue in some of the introductory chapters of the present volume, that the student may become more familiar with the subject, by seeing it presented under different points of view, and may receive explanations and answers to certain queries and objections, that will naturally occur to his mind. He who consults his own reputation more than the benefit of his reader, will scarcely choose to write on subjects of science in the way of dialogue, as this form has fallen into disrepute, since the admirable dialogues of Berkley. But to those readers who have no opportunity of personal instruction, it is believed this mode will be particularly acceptable.

With respect to the principle of arrangement adopted in the following part of the work, I have regarded all minerals that have the same constituent parts, and the same crystalline structure, as belonging to one species, whatever diversity of colour or form they may present. In the arrangement of the classes I have differed from Haüy in many cases, not from a love of novelty, but from a desire to make the subject simple and intelligible. I cannot, for instance, be convinced of the propriety of classing lime-stone with salts, and I deem it more consonant to a natural arrangement, to exclude from the class of salts, all minerals that are insoluble in water and insapid.

To facilitate the knowledge of earthy minerals, I have prefixed to Book II. a tabular arrangement of them, according to their specific gravities and degrees of hardness conjointly; the utility of such a table will, I trust, be more evident, in proportion to the practical application which may be made of it. It is, I believe, the first attempt to make these characters jointly the basis of an arrangement, intended to assist the student, in discovering the names of the species he may meet with. In ascertaining the hardness of many of the minerals in this table, was assisted by my friend Mr. Lowry, of Titchfield-street. To those who know him, this will be the best proof of correctness I could offer; the accuracy of his observation being only equal-led by the extent and variety of his knowledge, particularly on all subjects connected with mineralogy.

In that part of the work which treats of the natural history and characters of minerals, I have made frequent references to the splendid collection of minerals in the British Museum, which is open to the inspection of the public; to those who have the opportunity of visiting it, such references will, I trust, be acceptable and instructive, as the simple inspection of a mineral will give a better idea of many of its characters, than can possibly be conveyed by the most elaborate description.

In the class of metallic minerals, each metal properly constitutes a genus, and the different species of ore belonging to each genus have generally some common chemical character, by which they may be easily recognised; hence in the minerals belonging to this class, the chemical characters are far the most important, and it is to these that the learner should direct his principal attention. I have given, as far as the limits of the work would admit, a sketch of the natural history of each genus, before describing the species.

With respect to combustible and saline minerals, the characters are so definite, that the student can have no difficulty whatever in this department of the science; it is, therefore, treated concisely.

Mineralogy is a branch of natural history, and he who would obtain a just and comprehensive view of the subject, must not confine his attention to minerals as they are arranged in cabinets, but contemplate them as they occur in their native repositories; he should endeavour to trace the connection between different species of minerals, and the changes which they undergo by processes of natural chemistry; — changes which cannot at present be imitated in our laboratories. Persons who live principally in large cities, and only view minerals in cabinets, are led to entertain the idea, that in the mineral kingdom, nature is in a state of profound repose, and that all the different minerals at present existing, are coeval with the globe itself. It is true, that when minerals are taken from the mine and placed in cabinets, they appear to undergo no further change, and to be imperishable; but in their native repositories, changes are constantly though slowly taking place; they increase in size, advance to maturity, and afterwards decay more or less rapidly, though the life of a mineral, if we may use the expression, extends far beyond the duration of life in animals or vegetables.

It is worthy of particular attention, that certain species of minerals, very dissimilar in their composition, are almost always associated together. Now, to use the words of the late Bishop of Landaff, "Though it may be too much to infer, that one of these substances arises from the natural decomposition of the other, juxtaposition in the bowels of the earth, being no certain proof of their being derived from each other; yet the mind cannot help conjecturing, that a more improved state of mineralogy will show some connection in their origin." Watson's Chemical Essays, vol. iv.

When the same species of mineral, from different parts of the world, always contains a certain substance, which appears to the superficial observer to be foreign to it, the common origin of both substances may be inferred with still greater probability. Thus the common ore of lead (galena) almost invariably contains a portion of silver. This is the case with the common lead-ore in every part of England, though not a particle of silver-ore has been discovered there except in Cornwall and Devonshire. Such facts particularly deserve the attention of the philosophical mineralogist, and I have been careful to notice them, in order to excite a spirit of inquiry. Can we say in the above instance, that the lead was forming into silver, but was arrested in its progress, or is the change now taking place? I do not deem it unphilosophical to believe, that the vivifying influence of creative energy descends to the deepest recesses of the earth, acting according to laws as regular as those which govern the motion of the planets in the heavens.

> "Mens agitat molem et magno se corpore miscet."
> VIRG.

> ———————— "One pervading soul,
> Fills the great mass, and mingles with the whole."

The combined effects of magnetism, electricity, crystalline polarity, and chemical affinity, are probably united with other causes at present unknown, producing all the various changes in the mineral kingdom, including volcanic phenomena. But in whatever manner these changes are effected, they are undoubtedly going on, and he who views the mineral kingdom as an inert mass of heterogeneous elements, and confines his attention exclusively to cabinet collections, in order to obtain a knowledge of nature, is "seeking the living among the dead."

Unfortunately, the objects of mineralogical research are placed at a considerable distance from the residence of men of science, who are therefore seldom able to observe them in their native repositories, and working miners are little qualified to describe the phenomena presented to their notice.

It was said by one of the ancients, that the world would be well governed whenever kings were philosophers, or philosophers became kings; we may say with greater truth, that mineralogy will become a perfect science, whenever working miners are enlightened mineralogists, or enlightened mineralogists become working miners: but as these events are beyond the sphere of probable occurrences, neither the politician nor the naturalist need stop to anticipate the result of their accomplishment.

The attention of mineralogists has been too much devoted to the discovery of new species that possess no importance in nature, and can be of no use in the arts; or they have been engaged in the useless labour of inventing new names, and classing as new species every variety they meet with, attaching the names of distinguished characters, to minerals which have neither use nor beauty to recommend them to our notice. Can Werner or Haüy derive honour from having their names affixed to such minerals? What should we think of the taste or good sense of the naturalist who affixed the names of Linnæus, La Marck, or Cuvier, to any newly-discovered variety of gnat, flea, or bug? but a similar absurdity is frequently committed by mineralogists. This frivolous practice of changing and multiplying names probably originated with mineral dealers on the Continent, who were thus enabled to multiply their specimens, and to obtain a high price for substances which possessed no recommendation whatever, but their supposed rarity.

As some apology for the attention which has been devoted to substances of little use or importance on account of their scarcity, it may however be right to remark, that in the present state of the science, mineralogists are like the searchers for diamonds in the mines of India, who are obliged to pass every stone between the eye and the light, lest they should inadvertently throw away a diamond. That I may part in good temper with those who attach more importance than I do to the discovery of new mineral species merely on account of their rarity, I shall beg leave to conclude with a few observations connected with the subject that I have sometimes delivered in my lectures, when treating on crystalline and magnetic polarity: — We ought to be extremely cautious in denying the value of any discoveries in nature or in science, because their application to useful purposes may not be immediately obvious. How greatly would the heroes and statesmen of antiquity have despised the labours of that man, who devoted his life to investigate the properties of the magnet; little could they anticipate that this humble mineral, was destined to change the very form and condition of human society in every quarter of the globe. Let us bear in mind, that the magnet was known nearly two thousand years before it was applied to any purpose of practical utility. During that time the ocean was a fearful and trackless abyss, and voyages were confined to short excursions along the shore. The wanderings of Ulysses, which took ten years to accomplish, did not exceed in extent and difficulty the voyage from Dublin to London. When magnetic polarity was applied to the aid of navigation, mankind seemed to have acquired a new sense; guided by this mysterious power, Vasco de Gama and Columbus, led the way to the Eastern and the Western World, and a fresh impulse was given to the human mind, which had been slumbering for centuries. There is not a country inhabited by man where the influence of this discovery has not been felt; it has been the parent of our naval and commercial greatness, and has obtained for us the commanding rank we hold among the nations of Europe. The history of the magnet should teach us not to despise any discovery in science because its utility can not be immediately perceived. Some discoveries are unproductive, until the progress of science in a future age, directs their application to purposes of eminent utility. Such discoveries may be compared to the acorn, which may remain for a time buried in an arid soil, until stimulated by the genial rains of heaven, it strikes its roots into the earth, and springs forth to day — humble indeed in its first appearance, and slow in its progress to maturity, but destined at length to become a mighty oak, stretching its arms amid the skies; the ornament, the strength, and the glory of the forest.

June 21. 1819.
13. *Tavistock-Street*, *Bedford-Square*.

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N. B. *The Author undertakes the Mineralogical Survey and Examination of Estates. Letters may be addressed to him at Mr. Harding's,* 36. *St. James's Street.*

AN

INTRODUCTION

TO

MINERALOGY.

BOOK I. — CHAP. I.

Preliminary Observations — What are the essential Properties that distinguish a Mineral from a Plant or an Animal?

B. WHAT can possibly have detained you so long? I lost sight of you when I was crossing the ravine below the waterfall, in our descent from Honister Cragg. *

F. Just below the slate-quarry, I saw something on a rock near the right side of the path, which shone like a star; I climbed to it with some difficulty, and found several of these gems adhering to a mass of white stone in the slate-rock. The more perfect ones I got from a deep cleft in the rock, and I left others larger but less brilliant, that I could not break off. They appear almost as brilliant as diamonds; they will also cut glass, as

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* A magnificent rock, near Buttermere Lake in Cumberland.

I have tried upon my watch-glass. I am very anxious to know whether they are really diamonds; but I see you smile, and I fear my expectations will be disappointed.

B. They are not diamonds, but they may be more useful to you than diamonds generally are to their possessors.

F. Do, sir, inform me what they are called, they must be jewels of some kind.

B. The knowledge of the name would in itself be of little use; the transparent ones are called by mineralogists rock-crystals, and those which are less transparent are called quartz-crystals. They have different common or trivial names in different parts of England. In the vicinity of Bristol, they are called Bristol stones; and in Derbyshire, they are called Derbyshire diamonds.

F. Then they are, I suppose, an inferior kind of diamonds.

B. If you please to call brass an inferior kind of gold, or quicksilver a kind of silver from some similarity of colour or name, you will confound together substances that have properties essentially distinct, as your knowledge of chemistry will be sufficient to demonstrate.

F. Do these rock-crystals differ as much in their nature and properties from diamonds, as brass does from gold? They are brilliant and hard, and resemble diamonds so much, that I do not think I could distinguish them from real ones, were they placed on a table together.

B. You should recollect, that the diamonds you have seen were not in their native state, they had been cut and polished by the lapidary. Rock-crystals are sometimes cut and polished, and employed for ornaments, and ignorant persons have purchased them for diamonds. There is one easy mode of distinguishing them, should you fail to perceive any difference in their brilliancy. The diamond will cut rock-crystal with more ease, than the rock-crystals scratched your watch-glass.

F. Then cutting glass is not a property peculiar to the diamond.

B. Several minerals will cut or scratch glass; the white opaque stone that one of your crystals adheres to, will scratch glass almost as easily as the crystals themselves.

F. This stone has no resemblance whatever to the diamond; it is a part of the mass in which I found all the crystals. What is it called?

B. It is essentially of the same nature as the crystals, and is called quartz; they are both composed of silex, or the earth of flints, but the quartz is uncrystallized and opaque.

F. Then does all the difference between them consist in one being crystallized and the other not; they appear substances essentially distinct.

B. The difference which strikes you most forcibly is principally the opacity of the quartz; were they both pulverised, they would form a white opaque powder, possessing precisely the same properties.

F. I have seen the crystallization of salts from saline solutions, is the rock-crystal formed by a similar process?

B. Rock crystals were the first crystallized substances that the ancients appear to have noticed; they supposed that rock-crystal was water permanently congealed; hence the word crystal is derived from the Greek *Krustallos*, which signifies *ice*. In chemistry and the arts, the effects of crystallization are the same as in the mineral kingdom. Sugar-candy is crystallized sugar, and differs in appearance as much from raw sugar, as rock-crystal does from opaque quartz. Sugar becomes transparent by crystallization, and you know that alum, salt-petre, and common salt, when crystallized, take certain forms peculiar to each. Crystals of common salt are cubical, those of alum are octahedrons, and those of salt-petre six-sided prisms. The rock-crystal you have in your hand is a six-sided prism terminated by a six-sided pyramid, which is its most common form. Now we may infer from this similarity of effects, that the process of crystallization in all these substances, depends on one general law, modified by the nature of each.

F. But is it reasonable to suppose that this rock-crystal which is so hard, was ever dissolved in water like sugar, or the salts you mentioned?

B. The supposition is not necessary, though it may not be so absurd as you imagine, for the same earth of which the rock crystal is composed, is dissolved in the water of boiling springs. — It is not, however, required that all bodies should be dissolved in water to crystallize. You recollect the experiment of the melted bismuth crystallizing as it cooled, and most substances that are capable of being melted, would crystallize perfectly, if they were kept a sufficient length of time in a melted state, and suffered to cool very slowly: by a more rapid cooling, a confused crystallization may take place, or all trace of crystallization may be effaced. In order to produce regular crystallization, the atoms or particles of bodies should be in a condition to move freely among each other. Many substances that are rendered volatile by heat also crystallize when the heat is abstracted, and form crystals lining the vessels in which the experiments are made. If we could obtain sufficient heat to render quartz volatile, it might form crystals on cooling.

F. Am I then to believe that this hard crystal was ever dissolved in water, or rendered liquid by heat, or even made volatile at a still higher temperature?

B. You may for the present take whichever supposition appears to you most probable; but we are not sufficiently advanced in our enquiries to discuss this question. There is, however, another mode of formation that may be mentioned. Some philosophers have maintained that minerals are formed by a living principle, analogous to that in vegetables or animals, but of a lower kind, and differing perhaps as much from vegetable life as the latter does from animal life?

F. Do you mean to say that minerals grow and live?

B. The question has often been asked, whether stones and other minerals grow, and I think the most common prevailing opinion is that they do. It should not therefore appear unreasonable to those who hold this opinion to believe that stones are also alive; but it is not of the vulgar opinion that I was speaking.

F. Indeed, sir, have grave philosophers ever maintained that stones are living beings? What an absurdity!

B. It is frequently more easy to laugh at an opinion that is contrary to our received notions, than to prove it to be either absurd or erroneous. Those naturalists who first asserted that vegetables possess some degree of sentient vitality, were regarded as visionary theorists. It is now, however, generally admitted, that vegetables possess at least one property of animal life, irritability, and in some cases their motions appear analogous to the instinct of animals: it is further admitted, that the line of demarcation betwixt vegetable and animal life in some of the zoophytes is not easy to be traced. In the mineral kingdom, there are also processes which bear at least some resemblance to vegetation. But I merely mention these opinions to introduce a question which I would propose to you — 'What is a mineral?' Or, in other words, 'What are the essential properties that distinguish a mineral from a plant or an animal?'

F. I do not find it so easy to answer the question as I at first supposed, and shall thank you to inform me what those properties are that characterize a mineral.

B. The term mineral in common life is generally applied to denote substances dug out of the earth, or obtained from mines; but the exact import of the word in this sense is vague, and has given rise to some expensive law-suits. For in the sale of land the right to the minerals is often reserved to the lord of the manor, and the courts of law have been sometimes called upon to determine whether stone and coal are minerals, or whether the term should be restricted to metallic substances. We are not, however, now requiring such a definition of a mineral as may be admitted in law, but in natural history, of which mineralogy is a branch. The French mineralogists comprise under the term mineral, all the inorganic substances that exist in the earth, or float upon its surface.

F. According to this definition air and water are to be denominated minerals, as well as metals and stones.

B. Yes; but this definition appears to me more comprehensive than convenient for the purposes of science. The elements, or constituent parts of air and water, do enter into the composition of many minerals as well as water itself; yet as they are not known to exist in the mineral kingdom in a separate concrete state, I think it better to class such substances as elementary matter, and refer the consideration of their properties to the chemist.

F. What then do you admit to constitute the essential characters of a mineral?

B. The perfect sameness or homogeneity of its parts, and the manner of its formation.

F. I thought the principle of life constituted the essential difference between a mineral and a plant or an animal; animals and plants are living beings, and minerals are dead matter.

B. According to this definition, the piece of beef we expect to dine upon must be a mineral.— We have in our mineral systems rock-milk and rock-butter; mineral beef will be a new species.

F. Pray inform me what I am to understand by the perfect sameness or homogeneity of the parts in a mineral?

B. A mineral, by which term I mean a simple mineral unmixed with any other, is a substance composed of the same elementary or constituent parts throughout its whole mass; a fragment, however small, broken off from any part of it, is perfectly similar in its nature to every other part. A fragment from a mass of pure gold, or of that rock-crystal, may be regarded as a type of the whole of each; whereas a bone, a fibre, or a hair taken from an animal, will not represent the whole substance of the animal; nor will a piece of bark, or a leaf, represent the whole tree.

F. What is the precise meaning of the term *simple minerals?* Are they minerals composed of only one constituent elementary part?

B. A mineral that is unmixed with any other mineral is said to be simple, to distinguish it from those masses in which two or more minerals are united and blended, as in many rocks. A simple mineral is sometimes composed of only one constituent element, as pure native gold; for as this metal has not yet been decomposed, we must, in the present state of science, call it a simple elementary substance. The same may be said of the diamond. But the greater number of simple minerals are composed of several different constituent parts.

F. Then such simple minerals are in reality compound substances, are they not?

B. The chemist regards them as compound substances; but the mineralogist views them as they exist in nature, and considers those minerals as simple, and belonging to one species, that contain the same constituent parts combined in the same proportion. This similarity of composition is also attended with a similarity of form and structure in crystallized minerals. — Different specimens of the same species, if pure, should contain the same definite proportion of their constituent parts. Pure rock or common salt from Cheshire, from Poland, or from Africa, are similar in composition; and the rock-crystals you have found this morning are essentially the same as the rock-crystals of Mont Blanc or Dauphiny.

F. You said the mode of formation was another essential character that distinguished a mineral from an animal or a plant.

B. Yes; animals and vegetables increase by swallowing or imbibing substances often of a different nature to themselves, part of which is converted by certain organs into the substance of the plant or animal. This manner of increasing is called *intus susception*, and the process by which the food is converted into the substance of the plant, or animal, is called *assimilation*. Minerals, on the contrary, increase by the adhesion of minute atoms applied to the surface; these atoms are similar in composition to the mineral itself with which they unite.

F. Then minerals may be said to grow from without, and plants and animals to grow from within.

B. The growth of minerals, by the application of similar particles, is called increase by *juxtaposition;* it is well illustrated in the crystallization of salts. If a crystal fall to the bottom of the vessel, it ceases to increase on the lower side; and if you make a coloured mark upon a crystal of alum, for instance, when taken out of the solution where it was forming, and then replace it, the mark will be covered with a fresh deposition of saline matter as the crystal enlarges, whereas the mark of a wound on an animal or vegetable, remains on the surface of the skin or the bark, notwithstanding their growth afterwards.

F. Then, if I understand you correctly, simple minerals, that are of the same species, are similar in composition throughout their whole bulk, and are composed of the same constituent parts combined in the same proportion, from whatever country the specimen may come; and I think you said this similarity of composition was accompanied with a similarity of form and structure in crystallized minerals.

B. Yes, with certain limitations, what you have just stated is correct; but a small portion of other mineral matter may sometimes be intermixed, which may occasion a slight variation in the analysis of a mineral; but if it do not change the form of its atoms, or integrant molecules, and produce a change in the form of the crystal, the mineral matter so intermixed may be considered as accidental.

F. What do you mean by the integrant molecules or atoms, and in what do they differ from the constituent particles?

B. The constituent particles or atoms are the particles of each of the different elementary substances, of which bodies may be composed. Suppose any salt were composed of two parts of alkali, and one of acid, we may conceive one particle or atom of acid, uniting with two of alkali, to form one particle or atom of salt; and it is this atom, composed of the three constituent particles or atoms, that is called the integral molecule; a number of these molecules arranged in a certain order form a crystal.

F. Then the integrant molecule or atom of salt, or any mineral, is the smallest particle that can be separated by pulverizing it.

B. Perhaps we can never actually pulverize bodies, so small as to separate the integrant molecules from each other; but we can, in imagination, conceive this separation to be possible; and then any further division would change the nature of the substance; *viz.* it would separate the acid from the alkali, and we should no longer have the salt, but its constituent parts.

F. To what cause is the arrangement of the molecules into regular crystals owing?

B. The most probable cause that can be assigned, is a principle in some respects analogous to magnetic polarity. Each integrant molecule is supposed to be of a definite form, and to have poles of attraction and repulsion, like those of a magnet, which dispose particular sides of the molecule to unite with certain sides of other molecules in a regular order, and this is called *crystalline polarity;* on which I shall have more to say hereafter. But for the sake of illustrating a subject that generally appears difficult to learners, let us suppose the particles of sand and clay which form a brick, to represent the constituent atoms or particles of a mineral: the brick may represent the integrant molecule, and a building constructed of bricks may represent a number of integrant molecules arranged in a regular order, forming a crystal. We may carry the comparison farther, the mortar may be supposed to perform the function of that invisible power of cohesive attraction, which binds the molecules together, and the skill of the builder in placing the bricks, may supply the part of crystalline polarity, by which the molecules are disposed in a regular manner, and constitute a crystal.

F. Then if the bricks and mortar were thrown together in a heap and consolidated, they would represent the same mineral uncrystallized?

B. Yes, we should have the same matter without the regular form; hence uncrystallized minerals are said to be amorphous or shapeless.

F. Are not all minerals solid?

B. You may recollect that quicksilver is not so; but few, however, of the minerals described in our present systems are liquid; some exist in the form of dust or powder, and some are so soft as to crumble in the hand, these are said to be friable. But we have protracted the conversation perhaps too far; we are sufficiently rested after our mountain toil; let us return to the inn, and solace ourselves for the loss of your diamonds, with some of the mineral beef we were speaking of, for your definition would convert it into a mineral.

F. My appetite is too powerful to be conquered by definitions. I had forgotten my crystals, but pray how were they to be more useful to me than diamonds?

B. By exciting you to examine nature more closely, in order to gain a knowledge of the various minerals that you may meet with in your travels. This knowledge may sometimes prove of the highest use, by enabling you to ascertain the real value of substances that are presented to your notice; beside it will greatly increase the pleasure to be derived from travelling, for the acquisition of a new science is like the acquisition of a new sense; it enlarges the sphere of our intellectual power, presents Nature under a new aspect, and multiplies the objects of rational enjoyment.

CHAP. II.

On the Division of Minerals into Four Classes, and the Properties which serve to characterise each of these Classes.

F. WHILE you were writing, I have climbed to the top of High Steel*, above the deep chasm, which you said had the appearance of a volcanic crater. The air was remarkably clear, and besides all the principal mountains in Cumberland, I could see distinctly far over the western coast of Scotland, and even the north part of Ireland, and the blue mountains of North Wales appeared in the distant horizon. I could survey from this station four united kingdoms, if we may allow Wales to rank as one. But as I was resting myself on the summit, and enjoying the magnificence of the scene, our conversation of yesterday occurred to me, and I began to despair of ever becoming a mineralogist.

B. What could you discover in that extensive view to create despair?

F. I recollected that all these immense masses of matter belonged to the mineral kingdom; yet were I to examine them closely, like the mountain I stood upon, they would all seem so rude

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* A mountain close to Buttermere Lake.

and mis-shapen, and present such a variety of colours and appearances, that they would justify your comparison of the bricks and mortar, and materials of a building, thrown together in confusion and consolidated. I saw very few minerals in my ascent regularly crystallized; and as minerals have no organs to characterise them like animals or vegetables, I cannot conceive how they can be described in an intelligible manner. Some of the few crystallized minerals I met with may indeed be distinguished from each other. These yellowish-brown crystals have the form of the rock-crystals I discovered yesterday, and are equally hard, but they are dull and opaque: I should never mistake them for diamonds. Lower down I met with other crystals, so soft that I can scrape them with a knife. I wish you would inform me what they are?

B. The first is a mineral of the same species as the rock or quartz-crystal, but it is coloured yellow by an intermixture with the oxyd of iron, from which the rock-crystal was free. It is a brown quartz-crystal; if it were colourless and transparent, it would be rock-crystal.

F. I thought you informed me yesterday, that minerals of the same species had the same constituent parts; how am I to reconcile this with what you are now saying, that one of the quartz-crystals contains iron, and the other none?

B. Your knowledge of the leading facts in chemistry, will assist you in removing this apparent contradiction.

If you were to take a colourless solution of common salt, and pour it into two vessels, and add to one portion a few drops of almost any coloured infusion sufficient to give it a tint, you would find, on evaporating both portions of the solution, that the crystals of salt in that vessel would not be of so pure a white as in the other, but they would still have the same form, taste, and other properties, and remain the same species of salt.

We should therefore consider the colouring matter as an accidental admixture, which the process of crystallization could not entirely remove. In saline solutions, when any admixture takes place, it may, as you know, be separated in a great degree by crystallization; and the more slow and perfect the process, the more perfect will be the separation; yet it most frequently happens, that some sensible effect of such admixture may be traced in the crystals. Now if you carry the same views into the mineral kingdom, you will have no difficulty in conceiving, that minerals may be in some degree modified by the different substances with which they have been contiguous at the period of their formation. If the crystallization of a mineral has been rapid and imperfect, a portion of the contiguous matter may be enveloped n its substance; this cause may easily be conceived to produce certain differences in the appearance of two minerals of the same species, formed in different situations, and surrounded by different substances. In uncrystallized minerals, the same cause may produce greater changes, so as sometimes to make it doubtful to what species they belong.

F. Then it is only perfectly crystallized minerals that can be properly said to be pure and simple.

B. We can only be certain that minerals are in the highest state of purity, when they occur regularly crystallized; for any considerable change in the constituent parts would be attended with a change in the form of the crystal; but the most regular crystals may envelope small portions of other minerals, which may sometimes be seen imbedded within them: they frequently contain a very minute portion of foreign matter, sufficient to produce a change of colour *, as in the yellow crystal you hold in your hand, the colouring matter of which must be regarded as an accidental ingredient; and this holds good in most gems and in almost all earthy crystallized minerals.

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* The colouring matter of earthy minerals is generally metallic, but it often exists in too minute a quantity to be ascertained by chemical analysis. It is most frequently iron.

F. I confess I feel some degree of regret at this, for I expected to be able to discover the different species of minerals by their colour, and this would have made the study of minerals very easy.

B. In some minerals you will find the colour invariable, and then it is a useful character; but in many minerals the colour must be regarded as an accidental quality.

F. Is the soft crystal that I can scratch with my knife a softer kind of quartz-crystal?

B. No; it is essentially different, and is called calcareous spar: it is crystallized lime-stone. Quartz or rock-crystal is crystallized silex. You are acquainted with the difference of the two earths, silex and lime. The two crystals bear the same relation to each other that chalk * does to flint, and may be said to belong to two distinct genera.

F. Are there then classes, orders, genera, and species, in the mineral, as well as in the animal and vegetable kingdoms?

B. It should be recollected, that the arrangements in botany and zoology are introduced for the convenience of those who study these branches of natural history: they are creatures of human creation, differing according to the systems of different naturalists. In the mineral

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* Chalk is a soft variety of lime-stone, and flint may be considered as compact silex.

kingdom, the division into classes, orders, genera, and species, cannot be so conveniently made, nor so distinctly marked, as in the animal and vegetable kingdoms; nor has any system of classification been yet introduced, that is not exposed to many well-grounded objections; buts though erroneous or imperfect, these systems have been found highly useful to the student.

F. I do not clearly apprehend how erroneous and imperfect systems of any kind can be highly useful.

B. If we were never to make use of any thing that is imperfect, the business of life would stand still. Though the beef you had yesterday for dinner was badly cooked, and the dinner was defective, wanting proper vegetables, yet, hungry as we were, we found it highly necessary and useful to eat. — But to return to classification. The system of Linnæus, for instance, contributed much to enlarge our knowledge of nature, though it was in many respects imperfect, frequently overlooking the more essential differences in the physiology of animals, and giving too much importance to characters that were of less value. What could be more unnatural than classing men, whales, and bats in the same order? Yet, with all its defects, the Linnæan system of arrangement is perhaps better adapted to assist the memory of the student, and facilitate his early progress, than the more perfect systems that have since been constructed. Cronstedt was the first who divided minerals into four classes, a division which has been generally admitted by subsequent mineralogists; and though it be not strictly conformable to the present state of science, it is the most convenient basis of arrangement that we can receive.

F. How are the four classes named?

B. Saline minerals, combustible minerals, metallic minerals, and earthy minerals.

F. The division, I perceive, is founded in chemistry; we have earths, salts, combustible substances, and metals: how then can this arrangement be erroneous?

B. Your acquaintance with chemistry will enable you to answer the question yourself. Modern discoveries have shown that the metals, for instance, are combustible substances: even gold and platina burn with great brilliancy in the intense heat produced by a galvanic battery. The same powerful agent will reduce some of the earths themselves to metallic globules. The mineralogist, however, finds it more convenient to use the terms metals and earths, &c. in a popular sense. He considers those substances as uninflammable that will not burn in a common furnace; nor will he call the earths metallic oxyds, because small particles may, by very intense heat, be reduced to a metallic state. For the same reason he should withhold the name of salts from earthy minerals like lime-stone, which have no sapidity, and are not sensibly soluble in water.

F. How am I to know to which of the four classes any mineral belongs that is presented to my notice?

B. If you suspect it to be saline, the taste will discover it; or if, on immersion in hot water, it loses the greater proportion of its weight, it must be classed with saline minerals.* If you suspect it to be inflammable, a small piece should be laid on a red-hot iron; if it burn away wholly, or in a great part, you may class it with combustible minerals.

F. How am I to discover earthy from metallic minerals? I apprehend this will be more difficult; for I recollect seeing you put what I thought was a stone, into the bowl of a tobacco-pipe, and after heating it in the fire it came out perfect lead.

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* It is more convenient to class with salts those minerals only which are sapid, and sensibly soluble in water, than to class lime-stone, gypsum, &c. with saline minerals. Mr. Kirwan arranges all substances with salts that require less than 100 times their weight of water to dissolve them. To ascertain the exact proportion of salt in any saline mineral, let 100 grains, or a smaller quantity of the mineral pulverised, be put into a glass phial, and shaken up with thirty times its weight of warm water; filter the solution, and dry the residue: the decrease will indicate the weight of salt, and the residue, that of the earthy or metallic matter. Should the salt be of difficult solution, repeated quantities of boiling water may be used.

B. Metallic minerals may, with a few exceptions, be distinguished from earthy minerals by their greater degree of weight or specific gravity. If the mineral in question be five times heavier than water, you may class it with metallic minerals without any fear of being mistaken. We may extend still further the application of specific gravity, to ascertain earthy from metallic minerals; for, with the exception of a few minerals containing the earths called barytes or strontian, and the few rare minerals called by jewellers gems, all minerals whose specific gravity exceeds three and a half may be classed with the metallic.

F. How am I to ascertain whether minerals contain barytes or strontian; and by what means shall I distinguish the gems that exceed the specific gravity stated from metallic minerals?

B. The minerals containing barytes and strontian are not numerous, and may be easily recognised by characters that will be afterwards described. With respect to the gems that exceed in specific gravity three and a half, their great hardness will be sufficient to distinguish them, as they will all scratch quartz, which no metallic mineral will do. Their other characters will be noted in due time.

F. Are all minerals under the specific gravity of three and a half, except the saline and inflammable, to be classed with earthy minerals?

B. No; but the exceptions are so few, that it will be useful to enumerate them hereafter, that the rule may be made a general one. Specific gravity is one of the most important and definite characters; I am therefore willing to avail myself of its application, wherever it can be properly introduced.

F. With the instruction you have given me, I think there cannot be any great difficulty in determining to which of the four classes a mineral must be referred. But you have said nothing respecting stones and fossils. I suppose stones are included under earthy minerals; but I do not so well know what is meant by a fossil.

B. The earlier mineralogists made a distinction between earths and stones, but as chemistry has discovered that stones are composed of the earths, they are properly classed with earthy minerals. The term fossil is sometimes substituted for mineral; and as it is originally derived from the Latin, implying a subtance dug out of the earth, it might be retained without much impropriety, were there any use in having two names to represent the same thing. It is now more generally used to denote those minerals which have taken their forms from animal or vegetable remains; and which are called petrifactions or *extraneous fossils*, and sometimes simply fossils.

F. I should wish to know, before I proceed, whether I could ever make the information you have given me immediately useful; or what advantage could possibly be derived from merely knowing how to discover whether a mineral be earthy, saline, inflammable, or metallic?

B. This knowledge should be considered as only the alphabet of the science; there are cases, however, when it might be highly useful. You may remember a part of the Malvern-hills called the gold-mine. A former proprietor of the land had been at some expense in digging for a mineral, which he supposed to be gold, and was doubtless much disappointed by the result. The expense and disappointment might both have been spared, had he known the means of ascertaining whether the mineral he was in quest of was metallic or earthy.

F. What substance could he possibly mistake for gold in that situation?

B. It was a shining mineral called mica, which you will soon be acquainted with. It is a component part of many of the rocks at Malvern, and was found in considerable quantities at the place called the gold-mine, in the form of small scales, which the proprietor supposed to be gold-dust. Now the specific gravity of this mineral is less than three; it could not therefore be gold, or any of the known metals: he might thus, by its comparative weight, have discovered that it was not metallic. I knew a gentleman who lately was going to procure and send home, at a heavy expense, the same mineral from South America, mistaking it for gold-dust. I could enumerate many other instances, where a knowledge of the most simple and elementary parts of mineralogy would have been highly useful.

F. How is the specific gravity of minerals most conveniently ascertained?

B. If the bulk of the substance were precisely known, we should only have to weigh it, and compare it with the known weight of an equal bulk of water; one cubic foot of water weighing 1000 ounces avoirdupois. * The bulk of an irregular-shaped substance may be obtained by immerging it in a vessel full of water, as a quantity will run out equal to the bulk of the substance immerged; and if the weight of the substance is known, we have only to weigh the water which runs out, to ascertain the difference; this will inform us what is its specific gravity or weight compared with water. But as this method would be troublesome, and could not be

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* This is not precisely correct, the cubic foot of water weighing eleven grains less than 1000 ounces, but the difference is little more than one forty-thousandth part of the whole, which is too small to be regarded for practical purposes. A pair of gold scales that will turn freely with the tenth part of a grain, will be sufficiently delicate for ascertaining the specific gravity of minerals, except those which are very minute.

accurate, where the specific gravity of small substances is required, another more correct and convenient mode is adopted, which depends on the same principle.

Let the mineral be first carefully weighed, and its weight noted down; say, for instance, sixty grains. Let it then be suspended from one of the scales by a very fine thread or hair, and immersed in rain-water about the temperature of sixty degrees. It will be found to weigh less than in the air; suppose, when immersed, its weight is only forty grains, it has therefore lost twenty grains. Now this is what the same bulk of water would weigh, being equal to the water displaced by the mineral. The specific gravity or weight of the mineral, therefore, compared with that of water, is as sixty to twenty, or equal to three; or, briefly, the weight of the mineral in the air, divided by the weight lost in the water, gives the true specific gravity.

Grains in air. In water.
60 40 = 20 grains loss;
therefore 20) 60 (3, or $\frac{60}{20} = 3$.

F. How is the specific gravity of saline minerals, that are soluble in water, to be taken?

B. By weighing them in essential oil, the specific gravity of which is known. Where the specific gravity of fluid minerals is required, the method is still more simple. Let a phial with a narrow neck be first weighed, and then filled with water and weighed again; pour out the water, and fill the phial with the same quantity of the fluid whose specific gravity is unknown; and deducting the weight of the phial from each, you obtain at once the comparative weight, or specific gravity.

F. I thought there were instruments called hydrometers for this purpose?

B. Yes; but they cannot be so conveniently used by the mineralogist; nor, indeed, will he often have to take the specific gravity of fluids. As specific gravity is, perhaps, one of the best characters for distinguishing real gems from each other, when they have been cut and polished, it may be useful to have more delicate scales for the purpose.

F. Would the difference in the specific gravity enable me to discover false gems from real ones?

B. No; it could not be depended on, as it is possible to make the specific gravity of artificial gems the same as that of real ones. With respect to real gems, their specific gravity may serve to distinguish two different species from each other, but a very accurate and delicate balance would be necessary. *

F. Will the specific gravity of a metallic mineral enable me to ascertain to what species it belongs?

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* See Chap. VIII.

B. Only in cases where the metals are found in a native state. It may serve also to ascertain the proportion of two known metals that are alloyed together; for which purpose, the rule I will give you may be useful; and as I do not know any work on mineralogy or chemistry that contains it, I would recommend you to write it in your pocket-book.*

F. From our conversation of this morning, I learn that each species of simple mineral is not composed of an infinite variety of elementary parts, but is reducible to a few simple principles, and that minerals admit of a chemical division into four classes. I should now wish to be informed how the orders, genera, and species, are to be arranged?

B. The orders and genera are not so well characterised as the classes; indeed they may be

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* The specific gravity of the alloy or mass, deducted from the known specific gravity of the heavier metal, will give the proportion of the lighter metal; and the specific gravity of the lighter metal, deducted from that of the heavier, will give the proportion of the heavier metal. Suppose I have a mass of alloy weighing 100 grains, the specific gravity of which is 8½, and it consists of silver and copper: —

Then 8½ deducted from the specific gravity of silver, say for example 10½, leaves two parts of copper.

Specific gravity of copper, say for example 7½, deducted from 10½, leaves three parts of silver; or 60 grains silver, 40 copper in the mass; or let the heavier metal be $= a$, t lighter $= b$, and the alloy $= c$.

then $a-b$. the proportion of the heavier metal,

$a-c$. the proportion of the lighter.

regarded rather as arbitrary than natural: but to understand the principles on which any useful systematic arrangement can be formed, it will be necessary to make you better acquainted with the properties that serve to characterise minerals. You could not acquire a distinct idea of any system of classification in zoology and botany without knowing something of the structure and organs of animals or plants, on which these systems are founded; and though minerals, as you observed, have no organs, there are certain properties which the mineralogist employs, in order to distinguish and class them. These are properly called characters; but we must defer our explanation of them at present, for the horses are waiting at the door.

CHAP. III.

What are the Properties that serve as Characters to distinguish different Species of Minerals? — Physical Characters.

F. In our late conversation on Mineralogy, you said that there were certain properties which serve to distinguish different species of minerals from each other, and which are therefore called characters; — in Chemistry, a particular species of salt may often be ascertained from the form of the crystals, and I should suppose that crystallization offered the most distinguishing character of minerals, were it not that I see but few minerals in nature perfectly crystallized.

B. Your observation is just. Crystallization, when perfect, presents one of the most important characters; and the crystallographer, by studying the structure and properties of minerals in this perfect state, has brought mineralogy to the form of a science depending on definite laws. The Abbé Haüy has well observed, that when crystals are called the flowers of the mineral kingdom, the expression conceals a very just idea, under what appears at first only an ingenious comparison. Does not the botanist (says he) examine the organs of a flower in preference to the leaves or the bark, when he would characterise and class a plant, because these organs vary the least, although they have only a fugitive existence, and are often scarcely perceptible without the aid of a microscope: they are atoms which are lost in the imposing spectacle presented by the mighty trees that people the forest!"* I would carry this comparison further than M. Haüy. Were a traveller to pass through the forest at a season when no flowers are to be seen on the trees, he must avail himself of the other characters presented by the leaves, the bark, the trunk, or the branches, if he would discover to what genera or species they belong. So when minerals occur uncrystallized, which is frequently the case, we want other characters beside the crystalline form, to enable us to distinguish and class them, and are compelled to make use of such as are offered to our notice, though they may be less scientific or definite.

F. How are the characters of minerals to be discovered?

B. I have before said, that the characters are the properties which serve to distinguish minerals, and the properties of bodies can only be known by their immediate action on our senses, or from the observable changes produced by the action of bodies on each other. Those properties which are most obvious to the senses, or can most easily be made so, and which are at the

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* Tableau Comparatif.

same time the most characteristic, are what the mineralogist should select in describing a mineral. They are of two kinds, physical and chemical.

F. What are the physical characters?

B. The physical or natural characters are those properties which are obvious to the senses, or which can be made so without decomposing a mineral. Thus colour, which is one of these characters, is immediately obvious; and hardness, which is another, can be made so by rubbing a mineral on some other substance. Electricity, which is a character of some minerals, can be made perceptible by heating or by friction: whereas the principal chemical characters, which are fusibility and solubility in acids, cannot be made sensible without changing the nature of substances, *viz.* either by decomposing or dissolving them.

F. What are the principal physical characters of minerals.*

B. They are, *specific gravity*, *hardness*, *structure*, *frangibility*, *colour*, and *transparency*.

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* Some mineralogists make a distinction between physical and external characters. Mr. Jameson defines external characters to be "*those which are discovered by means of the senses, and which have no reference to their relation to other bodies, or to chemical investigation.*" But we may ask, how are hardness, frangibility, or specific gravity, to be known or estimated, except by their relation to other bodies? All the external characters of Werner are properly physical.

Beside these characters, some minerals present an irridence or play of colours; others are opalescent; some yield light on being rubbed or heated; some become electrical by the same means. A few minerals are magnetic; some adhere to the tongue; some feel unctuous to the touch; and a few have a peculiar taste or smell.

F. Will you explain the precise meaning of the terms employed to designate the physical characters, as used by the mineralogist; and how I am to apply my knowledge of these characters to the discovery of minerals?

B. I will commence with the colour; though it serves to characterise with certainty only the metallic and inflammable minerals, yet as it is the quality that first strikes the senses, it may be right to make use of it, wherever it is available. Indeed, though earthy minerals generally derive their colour from what may be called an accidental admixture, yet sometimes the colouring matter is an essential component part, and even in minerals; where it is not so, there are certain colours which most frequently occur, and which may be regarded as the prevailing colour of the species. The range of mineral colours includes all the colours that occur in nature; it would be, therefore, a useless labour to describe them. Each principal colour should have its particular kind noticed: thus green may be grass-green, olive-green, verdigrease-green, &c.: red may be blood-red, crimson-red, scarlet, &c.: and white may be snow-white, milk-white, reddish-white, &c.

The colours may vary in their degree of intensity, but these variations admit of a clear description in common language. There are, however, certain affections of light, produced by a tendency to decomposition on the surface of a mineral. The colour may be tarnished, or an irridescence or rainbow-colour may be seen on some metallic minerals, similar to what you sometimes observe on the heated bars of polished steel grates. The tarnish and irridescence of metallic minerals are owing to oxydation or decomposition. The colouring matter in earthy and saline minerals, as I have before mentioned, is either metallic or inflammable; the earths and alkalies, when pure, being perfectly white.

F. The next character or transparence, I think, will be easily understood.

B. Yes; some minerals admit the form of bodies to be distinctly seen through them; such are perfectly transparent. Where the form is only indistinctly discernible, they are semi-transparent; and where the light passes through without showing the form, they are translucent. To illustrate this by a well-known artificial substance. Window-glass is perfectly transparent; the coarser kind of bottle-glass is often only semi-transparent, and ground glass is translucent. Many minerals that are opaque in large masses, are translucent in small splinters, or on their edges, as flint.

F. If minerals of the same species are sometimes transparent and sometimes opaque, what is the cause of their opacity?

B. A mineral may be rendered opaque by the admixture of metallic or inflammable matter; producing in the first or lowest state a degree of cloudiness, which may increase to perfect opacity. Or a mineral may become opaque by a certain arrangement of its molecules, disturbing or destroying the continuity of its substance.

F. I do not understand what is meant by the continuity of the substance.

B. When a sheet of ice is without cracks or flaws, it forms one continuous transparent substance. If it be broken into very small pieces, the continuity of the parts being destroyed, it becomes white and opaque; for almost all the light is reflected from a number of small surfaces, instead of being transmitted through, as it was when there were only two surfaces. If the water were agitated during its freezing, the ice would also lose its transparency, owing to the great number of small surfaces produced by disturbed crystallization.

The most transparent glass may be rendered opaque by keeping it in the furnace a long time at a high temperature; owing to the molecules arranging themselves in distinct fibres or crystals, instead of forming one continuous even mass, the surface of each of these fibres or crystals reflects a portion of the light. If you pulverise glass, it forms a white powder; but each particle, when viewed separately, is transparent. I have given you, I hope, a sufficient number of instances of opacity, produced by destroying or disturbing the continuity of substances.

F. What is meant by the lustre of minerals?

B. The lustre is produced by reflected light, and is independent of the colour. It may vary both in kind and in degree of intensity, metals being perfectly opaque *; the light is reflected without penetrating the surface, producing that peculiar lustre well known by the term *metallic lustre.* It is exhibited by all the native metals, and by some metallic ores.

The metallic lustre, with the exception of plumbago (commonly called black-lead), is peculiar to metallic minerals; but there is a mixed kind of metallic lustre, called semi-metallic, which is reflected from some of the earthy minerals, as well as from several ores of the metals. This

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* It is probable that the molecules of all bodies are transparent. Gold, which is one of the densest metals, transmits green rays of light when it is beat out into leaves, as may be seen by holding a leaf of gold between the eye and the sun.

lustre is destroyed by scraping a part of the surface, which is not the case with the true metallic lustre.

F. Can the lustre of quicksilver and of black-lead be of the same kind?

B. Yes; they are both of the same kind, but they differ in degree, the one is highly splendent, and the other only feebly shining. I have said before, that lustre is independent of colour. A plate of gold, and another of tin, might both be polished to reflect the same quantity of light; they would then have an equal degree of lustre, though the colour of each would differ. The resinous lustre is of the same kind as that reflected from resin or pitch, and the vitreous lustre as that reflected from glass. There are other kinds of lustre which depend partly on refracted light. The adamantine lustre derives its name from the Latin *adamas*, the diamond: it is produced by the light which, after it has penetrated the surface, is reflected back, undergoing a certain degree of refraction. This lustre is only possessed by those minerals that have a high degree of refractive power. The pearly lustre, like that of pearls, is produced by internal reflection sometimes combined with refraction, but the light does not penetrate far before it is reflected.* Translucent fibrous

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* If a number of watch-glasses are laid upon each other with their convex sides upward, the light being reflected from

minerals reflect a changing light like that from silk, which is called the silky or satin lustre.

F. You described the method of ascertaining the specific gravity in our last conversation, have you any further observations to make on that character?

B. It is often useful to try the specific gravity of minerals in a rude manner, by poising them in the hand when we are selecting minerals for further examination. It may also be proper to remark, that inflammable minerals are very light when pure, being rarely twice the weight of water. Mineral oil swims in water; a very few solid minerals are also lighter than water, or supernatant. Minerals which range from 2,5 to 3,5 may be called rather heavy; above 4 they may be called heavy; and those which exceed 6 very heavy; and are thus designated on the Wernerian method.

F. How is the hardness of minerals to be ascertained?

B. The hardness of minerals depends on the cohesive attraction, by which the molecules are bound together, and is most correctly ascertained by their cutting other substances which have a permanent degree of hardness, or by their being

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several interior surfaces, will yield a pearly lustre. This simple experiment is illustrative of the cause of the pearly lustre in minerals.

cut or scratched by such substances. Crystallized quartz, window-glass, fluor spar, and calcareous spar, are used for this purpose. A knife with two blades, one of copper, the other of steel, and a small well-tempered file, may also be employed. According to the resistance which minerals yield to these instruments, they are called by Werner extremely hard, hard, rather hard, and soft; but these terms being indefinite, it is much better to state the precise degree of hardness, as proved by trial.

F. I have frequently heard giving sparks plentifully with steel spoken of as a test of the hardness of bodies.

B. This mode of trial cannot be relied on; for M. Haüy has observed, that the quantity of sparks produced when a mineral is struck on steel depends on other circumstances beside the hardness. Many minerals that are much harder than flint possess less power of eliciting sparks.

F. I observed the other day the great difficulty with which a stone broke in pieces that you were striking with the hammer; but I recollect that I could cut it easily with my knife. The knife is not, therefore, in such cases, a good instrument to discover the hardness of minerals.

B. You are now confounding together two qualities that are very distinct, hardness and frangibility; the latter quality in animal and vegetable substances is frequently called by the more expressive name toughness; the difference between them may be thus illustrated: You could cut a tendon with a knife more easily than a bone, but the bone might be easily broken with a hammer, though the tendon could not. I shall speak of the frangibility of minerals next, but it may be useful first to mention, that two minerals possessing the same degree of hardness, will cut each other, and in trying the hardness of minerals with a knife, it is necessary to observe whether the knife really make an impression upon the surface, or only breaks off minute portions, which may be the case with minerals that are composed of an assemblage of minute crystals or fibres.

F. I have still some difficulty in conceiving the difference between hardness and frangibility in minerals.

B. The hardness of minerals depends, as I before observed, on the degree of cohesion by which the molecules are bound together. In trying the hardness, we endeavour to separate the molecules from each other; in trying the frangibility, we endeavour to divide the mass into fragments. The greater or less ease with which this can be done depends on two causes, on the structure of the mineral, and on the cohesion of the molecules.

Many hard minerals having a crystalline structure, are composed of laminæ or plates; and these plates adhere to each other with less force than the cohesive force of the molecules in each plate, so that they will divide in the direction of the plates with a much slighter blow than across the plates. The frangibility is also affected by the greater or less degree of elasticity. Some minerals, instead of breaking, are bruised or indented by the hammer; such minerals are generally very tough or infrangible.

It may be useful to state, that minerals are often broken more readily by one smart stroke with a hammer when held in the hand, or laid on a feather-bed or cushion, than when laid on any hard substance. Many hard elastic minerals are very easily broken; the integrant molecules separating when a sudden vibration is produced, which removes them beyond their sphere of mutual attraction. The diamond, which is the hardest substance known, is easily frangible. When minerals are elastic and easily frangible, they are called brittle. When minerals yield to the knife, if they can be cut into coarse powder or shavings that do not fly off, they are called sectile. Common slate-pencils and chalk offer a good illustration of sectile minerals. Were you to attempt to cut a brittle mineral, the parts would fly off like those of glass. When the molecules, though they adhere with great force, yet admit of a certain degree of motion among themselves by compression, a mineral may be cut into thin slices, or extended by beating with a hammer; it is then said to be ductile. This property is possessed by some of the native metals; it is the highest degree of tenacity.

F. It does not seem obvious how the particles or molecules in a solid mineral can move.

B. It is admitted as one of the first principles in natural philosophy, that the particles of the densest bodies, as the metals, do not absolutely touch, for they are contracted by cold, and expanded by heat; they must therefore be at some distance from each other, though they are kept within the sphere of mutual attraction. The particles of fluids move easily over each other, but their mutual attraction is comparatively weak; they are therefore easily separated, and yield to the slightest impulse. The motion of the molecules in solids and fluids may be conceived as differing in degree rather than in kind. At high temperatures, the molecules of solid bodies are further separated, they become fluid, and at low temperatures fluids become solid.

F. What is meant by the fracture of minerals?

B. The fracture is the new surface produced when a mineral is broken. M. Haüy has properly considered this as distinct from the structure. The fracture frequently depends on the structure, but differs as much from it as the colour differs from the form, though these characters are confounded by Werner and his followers. The fracture is modified by the size of the parts connected together, their degree of coherence, and the irregular arrangement of the molecules, which all affect the shock produced by the stroke of the hammer, and give rise to different forms of the surface. This character is therefore often variable and vague. There are, however, different kinds of fracture which certain minerals must frequently present when broken by a smart stroke; these it may be proper to enumerate and describe. They are called *conchoidal*, or *uneven*, *even*, *splintery*, *earthy*, and *hackly*, to which some add *vitreous*.

F. Most of these terms are well understood in common life; I suppose they have a somewhat different meaning, as used by the mineralogist.

B. The only use of defining these terms is to restrict their application within certain limits. The *conchoidal fracture* resembles the convex or concave impression of shells, with smooth circular ridges and depressions. You may frequently observe this fracture in flint. When it is less distinct and irregular, it is called *imperfect* conchoidal; and when still more irregular, it passes into what is called *uneven*.

The *even fracture* presents few inequalities, and they are low and nearly flat. In the *splintery fracture*, a number of small wedge-shaped scales rise from the surface; similar scales are seen on breaking a piece of bees'-wax. The *earthy fracture* shows a dull, somewhat rough surface, as in chalk; and lastly, the *hackly fracture*, which only takes place in native malleable metals, presents low sharp-pointed fibres, or sharp inequalities, often discoverable only by the feel. I might add, that the shape of the fragments is sometimes noticed by mineralogists; but it is a character of minor importance, and may always be described with sufficient precision in common language; as wedge-shaped, splintery, tabular, sharp-edged, blunt-edged, &c.

F. What is meant by the external form, as a character of minerals?

B. Minerals, besides being crystallized in regular symmetrical forms, which are properly denominated crystals, are frequently found to have particular forms, resembling other objects in nature or art; this is called by some mineralogists, the particular external shape; but may more simply be denominated the *definite form;* and lastly, a mineral may have no resemblance to any particular form, *viz.* it may be *indefinite* or *amorphous.* Minerals are also sometimes found, which have taken the form or impression of plants or animals; this is called the *extraneous form.* Of the forms enumerated, the indefinite is the most common, and is therefore called sometimes the common form.

F. I will thank you to arrange them in the order in which they most frequently occur.

B. Then we must begin with the indefinite or common form; next the definite form; and lastly, the crystalline form; for the extraneous form may be regarded as accidental, and its consideration referred to other branches of natural history.

F. Is there any thing respecting the common form which you would wish me to notice? The greater number of minerals that I have yet seen have no resemblance to the shape of any known object, I suppose they would be described as being indefinite, or of the common form.

B. Yes; all these minerals have the common form, but they may be either large or small, or may be extremely thin in one direction, or may be scattered and imbedded in other minerals; all these modes have received particular names.

When a mineral has a considerable bulk in length, breadth, and thickness, it is said to be massive; if smaller than a hazel-nut, it is said to be in pieces. If the pieces are closely imbedded, and adhering in another mineral, they are said to be disseminated. When a mineral forms a thin crust on other minerals, it is said to be *plated;* and when this covering is too thin to be separated in a plate, it is said to be *superficial* or *investing.* A mineral may also occur in grains, or still smaller in loose powder or pulverulent. Minerals which have no distinct distinguishable parts are said to be compact.

F. What is there to be noticed in the definite form of minerals?

B. The definite form of minerals, as Mr. Kirwan has well observed, has frequently been caused by imperfect crystallization, the process having been disturbed either by agitation, or by pressure, or by the introduction of foreign substances, which have prevented the regular arrangement and mutual contact of the molecules. You may observe similar effects in crystallizations from saline solutions that have been disturbed or rapidly evaporated; or where the water was insufficient to hold all the particles of salt in solution, until a regular crystallization had taken place; or where there has been an admixture of foreign matter in the solution. The operation of heat either by a perfect or imperfect fusion, has given a particular form to some minerals, as the volcanic. The definite forms of minerals are numerous, and have received particular names from mineralogists. I shall enumerate and explain the principal ones, and will furnish you with a vocabulary of the others which may be useful, to enable you to understand the descriptions of mineralogists. The definite form has been divided into the longish, rounded, flat, and cavernous. The longish may be either *capillary* in thin small filaments like hair; *dendritic*, branching like a tree or plant; *filiform*, in thickish straight threads terminating in a point; *coralloidal*, branched like coral; *stalactitic*, resembling icicles; or *claviform*, like a club, thicker at its extremity, &c.

The rounded forms may be either perfectly or imperfectly globular; *botryoidal*, consisting of rounded segments in clusters, like grapes: if flatter and large, they are sometimes called *mamillated*, from *mamilla*, the female breast; *reniform* or kidney-shaped, &c.

The flat definite form may be *specular*, viz. flat and polished; or in leaves, plates, &c.

The cavernous may be cellular, with cavities or cells; *spongiform*, with cavities like sponge; or *vesicular*, with bladder-shaped cavities, &c.

The minerals that are globular are often composed of a number of concentric layers, and each of these layers is composed of fibres which seem to diverge from the centre of the sphere.

F. What is meant by the structure of a mineral? You have before stated, that it was as distinct from the fracture, as the colour from the form of a mineral?

B. The structure is derived from an arrangement of the particles or molecules more or less regular; it is often made visible by breaking a mineral, but the fracture which discloses the structure ought not to be confounded with the structure itself. The perfectly regular structure produces regular-shaped crystals; the consideration of these will be referred to a future conversation, as crystallography may be said to form a science of itself.* We shall therefore pass on to the other modes of structure, resulting from a confused or rapid crystallization. The fibrous structure, common to many minerals, presents a surface composed of fine threads or fibres, which are sometimes too minute to be discovered without the aid of a lens, or the fibres may increase in breadth till they form long and broadish laminæ. The fibres may either be parallel, radiated, diverging, or promiscuously arranged. The fibres are sometimes so loosely adhering that they may easily be separated from each other. When the fibres are very broad, the structure passes into the foliated or laminar, sometimes called lamellar.

F. What is the meaning of these terms in mineralogy?

B. They are used to denote thin plates or leaves of any mineral substance. M. Haüy makes a distinction between lamellar and laminar; the former structure he defines to consist of a number of minute lamellæ, laid

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* The Wernerian mode of describing crystals is given in the next chapter, and the theory of Haüy in the following chapters.

in different directions, as in statuary marble. In the laminar structure, the plates are laid regularly, and divide in certain directions, which are called the cleavage. The new faces obtained by the fracture have a smooth and polished surface, if the fracture has taken place in the direction of the laminæ or plates. Some minerals split with shining faces in two directions, and are said to have a double cleavage; some split with three or four shining faces, and are said to have a threefold or fourfold cleavage, which we shall more particularly explain hereafter. The laminar structure is called by some mineralogists foliated; and the laminæ are called folia, from the Latin *folium*, a leaf. In some minerals, the laminæ, instead of being straight, are curved; these are called curvedly laminar.

F. As the terms laminar, lamellar, and foliated, are used to express the same mode of structure, are there any peculiarities which are better expressed by one of these terms than by the other?

B. The terms lamellar and laminar are strictly synonymous, and are used indiscriminately by English mineralogists. Minerals are sometimes imperfectly laminar or lamellar, the plates or laminæ being uneven and rough. The slaty structure resembles the laminar on a larger scale, the thickness of the plates being considerable, as in the well-known substance roofing-slate.

F. Is the slaty structure the result of crystallization?

B. The perfectly slaty structure in some kinds of slate is evidently so, there being two distinct cleavages meeting under a certain angle, *viz.* the slate splits regularly in two directions which cross each other. This is crystallization on a large scale; the whole rock or mass may be regarded as the crystal, and the plates of slate as the laminæ.

In describing the laminar or lamellar structure, when a mineral has two or more cleavages, the angles under which the plates meet should be measured, as it is an important character. Some minerals, as felspar, are distinguished by two cleavages at right angles to each other, such are said to have a double rectangular cleavage.

F. Are these all the varieties of structure?

B. Minerals sometimes have a compound structure, splitting into thick laminæ in one direction, and these laminæ are themselves composed of fibres arranged in another direction.

F. I do not exactly comprehend this mode of structure.

B. If you were to saw the trunk of a tree across into a number of thin plates or discs, and place these on each other, the plates might represent laminæ in an horizontal direction, and the fibres of the wood in each plate might represent the fibrous structure of the laminæ, the direction of the fibres being perpendicular. Most frequently, the minerals which have this structure, are composed of curved concentric laminæ, having the fibres of each lamina arranged as if they were diverging from a common centre.

Some minerals occur in what are called *distinct concretions;* these are, globular, angular, prismatic, or laminar portions, adhering together, or united by a cement of the same kind, and forming a mass. Distinct concretions vary considerably in size, the large concretions are themselves frequently composed of smaller concretions, which are either granular, prismatic, or laminar; thus large globular or botryoidal concretions are often composed of concentric laminæ, or of prisms adhering together and radiating from the centre. The globular masses of pyrites found in the chalk rocks in many of the southern counties of England, offer a good illustration of distinct concretions. These masses, provincially called brass lumps, are found sometimes detached, and sometimes adhering to each other. When broken, they display very conspicuously brilliant radiated prisms, diverging from the centre. In this instance, we have large globular distinct concretions, formed of small prismatic concretions.

The *granular structure* is an aggregation of small distinct concretions or grains, and may be fine or coarsely granular. When no grains or parts are discernible, a mineral is said to be compact.

F. Are distinct concretions the result of crystallization?

B. Most distinct concretions are imperfectly crystalline; the process of crystallization appears to have been disturbed and modified by cohesive attraction, which united the parts before the crystals could be regularly formed. Some mineralogists have divided and subdivided these concretions into an almost endless variety. To enumerate or describe them would only serve to burden the memory, without being of any use whatever, as these varieties, when they occur, are all capable of being clearly described in simple and well-known terms.

F. Are the properties you have enumerated and described, all that you mentioned as forming the most important physical characters of minerals?

B. The remaining characters are more limited in their application, and serve to distinguish but a small number of minerals, I shall therefore briefly dismiss them.

Those minerals that absorb moisture rapidly, adhere to the tongue when it is applied to them; it is a property characteristic of some soft minerals. Some minerals feel unctuous or soapy, others feel particularly harsh. A few minerals yield a peculiar smell when rubbed; others, as the saline, affect the palate by a peculiar taste. Many of the ores of iron affect the magnetic needle, and almost all will do so, after they have been roasted in the fire, or acted on with the blow-pipe. Some minerals possess magnetic polarity, attracting at one end the north or south pole of the magnetic needle, and repelling it with the other; these are properly magnetic. Some crystallized minerals become electric by heating. I shall direct your attention to them when we enter more fully into the subject of crystallization. Minerals which give out light when they are heated or rubbed, are called *phosphorescent.*

F. The physical characters of minerals which you have described, do not appear to me so definite or capable of such precise application, as those which distinguish the different genera and species in Zoology and Botany. Many of them admit of insensible gradations, that seem to defy all definition; thus it must be almost impossible to describe all the different gradations from hard to soft; and in the different modes of structure, some you say pass insensibly into each other, and are besides frequently very indistinct.

B. Your observation is correct, but you must remember that I commenced by observing, that when the more certain character of crystallization was wanting, we must avail ourselves of the properties that are offered to our notice. Mr. Kirwan has well remarked, that "the external or physical characters of minerals, have been objected to as not being of a fixed and permanent nature, nor appropriated purely or singly to any particular species, but common to many, and incapable, at least in their gradations, of a definition sufficiently precise." "The first part of this objection is," says he, "certainly true, if applied only to one or two of these characters; but if they be taken in their totality, it will very rarely happen that they suit any mineral but one, and in such cases chemical tests may decide."

F. By chemical tests, I suppose Mr. Kirwan intends to discover the characters which you call chemical?

B. Mr. Kirwan expressly says, that he does not mean complete analyses, but tests capable of easy and speedy application. I am afraid, however, you have found the present conversation too long and uninviting; but there are certain parts of every science which must be studied for use only, and if I have made the subject intelligible, I have accomplished my object; to make it entertaining were perhaps impossible. I shall defer what I have to say respecting chemical characters to our next meeting.

CHAP. IV.

Properties which serve as Chemical Characters to distinguish Minerals. — Wernerian Method of describing Crystals.

F. At our last conversation, you observed that the chemical characters of minerals often indicate their nature in a direct and satisfactory manner; will you inform me what these characters are, and how I am to discover them?

B. The chemical characters are derived from the property of being soluble or insoluble in acids or in water, or of being fusible or infusible at certain degrees of heat, or from other changes these agents produce, in the external appearance of minerals.

F. What chemical changes are particularly to be noticed by the action of acids, and how are the acids to be applied?

B. Some minerals are *insoluble*; some are *partly soluble*, and some *entirely soluble.* Some dissolve *rapidly*, others *slowly*; some appear to *effervesce briskly* or *slowly*, others to *dissolve quietly*; and some *communicate a colour to the solution.* These changes must be noticed when they occur; they form distinct characters of many minerals. There is another character peculiar to some minerals. When powdered, they dissolve slowly in acids, and form a jelly, such are said to *gelatinize;* and lastly, some minerals in dissolving, give out a gas which corrodes the glass they are laid upon; this indicates the presence of fluoric acid. The acid most generally used, is the muriatic of moderate strength. A fragment of a mineral not larger than a grain of rice will generally be sufficient; it may be laid in the concavity of a watch-glass, and a few drops of acid poured over it. It may be convenient, in some cases, to use the nitric and sulphuric acids; but in travelling, a small glass phial, with a ground glass stopper, inclosed in a case for the pocket, and containing a small quantity of muriatic acid, will suffice. A glass rod and watch-glass will be useful; by dipping the rod into the acid, and touching the surface of a mineral, you may discover the various carbonates of lime, which will all effervesce more or less.

F. What changes are produced by the action of water?

B. These changes are partly chemical, and partly mechanical. Solubility in water is the property of the salts. Some earthy minerals absorb water and become plastic, and a few fall to pieces in water. These properties therefore serve as characters.

F. The action of heat is, I suppose, of more extensive application than the other chemical characters, as there is no substance but what may be changed by a most intense heat?

B. The mineralogist generally restricts the action of heat, as a chemical character, to the effects produced by a common blow-pipe, used with a lamp or a candle, and blown either by the mouth, or a pair of small double bellows.

The blow-pipe is a hollow tube about seven inches long, and about the diameter of a small reed at the thicker end, from which it tapers to a point at the smaller end, which is bent. The aperture at this point should not exceed that of a very small pin, except for some purposes; the air being blown through this tube against the flame of a lamp or candle, will produce a cone of deep blue light, the point of which must be made to act upon a small portion of the substance to be tried.

The greatest heat is at this point, and it is equal to the strongest degree of heat that can be produced by a blacksmith's forge, or about 125° of Wedgewood's pyrometer. This simple instrument is therefore a most convenient pocket furnace, if I may use the expression, enabling you to try the habitudes of minerals when acted upon by a high degree of heat, without any other preparation than lighting a candle. The heat obtained by the more complex mode of supplying the blast with oxygen gas, or a mixture of hydrogen and oxygen, melts or burns every known substance, and cannot therefore be used to try the fusibility of minerals. Many minerals are absolutely infusible by the common blow-pipe, as quartz and flint. This infusibility serves as one character. Those minerals are said to be *infusible per se* which will not melt when unmixed with other substances, for the most infusible earthy minerals will melt when mixed with alkalies, alkaline earth, or alkaline salts; the alkali in such cases is called the flux.

F. Will you mention a mineral on which I can make a trial easily?

B. Yes, a particle of flint or quartz will not, as I have before mentioned, melt with the greatest heat you can raise with a common blow-pipe; but if you add a little potash to it, the two substances will melt together, and form a globule of glass, similar to common glass, which is, as you know, composed of siliceous sand, and an alkali.

F. What is particularly to be remarked respecting minerals that are fusible?

B. If they melt without addition, they are said to be *fusible per se.* If they form a round globule, they are said to be perfectly fusible. When only the surface of the mineral melts, it is said to be glazed. If it form a *scoriæ* or *slagg*, it is imperfectly fusible; and when parts are melted, and other parts remain unaltered, it forms a *frit.* Metallic minerals present other characters. Many of the ores yield a globule of metal, and some metallic ores communicate a peculiar colour to glass or borax, when a minute portion is powdered and mixed with the latter substances. Some metallic ores that cannot be reduced to the metallic state by themselves, are reduced when laid on charcoal, either with or without the aid of fluxes, such as borax and soda.

F. Are any particular directions necessary in the choice or management of the blow-pipe? *

B. The most simple form is to be preferred; a tube that will take to pieces to inclose in a pocket-book will be the most convenient for travelling. The aperture at the nosle should be sufficiently large to give a steady distinct cone of blue flame from a wax-candle, but not so large as to require much effort to supply it with a sufficient quantity of air from the lungs. A piece of a thick wax-candle will give the best flame for the purpose. If you can contrive a rest for the blow-pipe by a moveable joint to be fixed to some steady support, it will afford you great advantage in the management of this instrument, by leaving both your hands at liberty. The great

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* The best and most ample instructions for the management of the common blow-pipe are given in Mr. Aikin's Manual of Mineralogy.

secret of keeping up a steady blast, is to begin with your cheeks inflated, urging the air through the blow-pipe by contracting them, and at the same time inspiring with your nostrils. A little practice will enable you to keep up a steady blast for several minutes without much fatigue. A spirit-lamp is convenient to use in a laboratory, but it does not give so strong a heat as the flame of a wax-candle. It has one advantage however; it may be always kept level with the nosle of the blow-pipe, where the latter has a fixed support. For earthy minerals, a pair of small platina pincers forms the most convenient support; the fragment of an earthy mineral to be tried should, if possible, be a small flattish splinter, not thicker than a pin, and a quarter of an inch long; it may be held at one end by the pincers, whilst the other is exposed to the point of the blue flame. Very fusible minerals, or those which decrepitate and fly off the support, may be tried in a small spoon of platina, or be folded in a leaf of platina, and exposed to the flame of the blow-pipe. A clean tobacco-pipe, broken down so as to leave a short stem for a handle, and only a small portion of the bowl, is a very good support when you want to try the colour which metallic ores communicate to borax. For this purpose, a grain, less than the head of a pin, may be mixed with a quantity of borax the size of a pea, both being pulverized together. This will suffice for three or four trials; a portion being laid in the broken bowl of the tobacco-pipe should be kept for a few minutes in a melted state, or till you perceive the colour diffused equally through the globule that will be formed.

For metallic minerals, a piece of close-grained charcoal should generally be used, making a small cavity to lodge a particle of the ore, the size of which should never exceed that of a small pea, but ought to be much smaller for those ores which fuse with difficulty.

F. Have you mentioned all the chemical characters to be noticed in minerals?

B. I have given you the most important, but it may be proper to observe, that some minerals intumesce or boil under the blow-pipe, some enlarge and separate into distinct parts; these are said to exfoliate. Some are volatile, and are dissipated by heat; others are partly dissipated; some yield a peculiar smell, and others give out light. Some minerals even present these characters when a small fragment is exposed to the flame of a candle. All these circumstances should be noticed when they occur, but I do not think there is any use in burdening the memory of the student, by an enumeration of every change which minerals undergo by exposure to heat. Some German mineralogists have, with tedious precision, enumerated and described nearly one hundred changes produced by the blow-pipe.

F. I suppose the remaining character, or crystallization, is what you will now describe; from the importance you attach to it, I am rather surprised it has been deferred to the last?

B. The study of the structure and forms of crystals, constitutes a science of itself, called crystallography; and by the aid of this science, combined with chemistry, mineralogy may perhaps soon be reduced to a few certain definite principles, and attain its highest degree of perfection. But to render a science more perfect, or to make the best practical use of what is already known in the science, are two very distinct objects. The first has occupied the chief attention of the celebrated Abbé Haüy, and the French school of mineralogists; the second of M. Werner, and the German school. The Wernerian method, as it has been called, may be said to teach the rules of an art, rather than the principles of a science: it is an art, however, highly useful in itself, and the knowledge of it is the best introduction to the more perfect system of Haüy.

F. Then do the German mineralogists entirely neglect the crystallization of minerals?

B. No, not entirely; this were scarcely possible. They notice the prevailing forms which are most common in each species, but describe them without any reference to their structure or mode of formation.

F. What, have minerals of the same species a variety of crystalline forms? This appears to contradict what you have before told me, that minerals of the same species are composed of the same constituent parts, and are crystallized in the same form.

B. It is true, there is an apparent contradiction between what I have been now stating, and the principle first laid down; but it is only an apparent one. Minerals of the same species, frequently occur under a great variety of crystalline forms; but the Abbé Haüy has discovered, that there is an internal crystal, a nucleus, which is precisely the same in every variety of crystal of the same species. This internal crystal or nucleus, he calls the *primitive form,* and the form in which crystals most commonly occur, he calls the *secondary form.* The Wernerian mineralogists take notice only of the common external forms, which are most frequently the secondary ones; for very few minerals occur crystallized in their primitive forms.

F. In what manner are crystals described by Werner, to make their forms intelligible to the student?

B. He supposes every crystal to be some well-known geometrical solid, which he calls the fundamental figure, and its deviations from that form to be produced by certain angles or edges having been cut off. I say, he supposes them to be so, for the convenience of description.

F. Are these fundamental figures of Werner the same as the primitive forms of Haüy?

B. No; they are the prevailing, or most common form of the crystals of each species; for it is observed, that amidst the great variety of secondary forms which sometimes occur in one species, there ~~is one~~ are certain forms more frequent than any other. These forms may be conveniently reduced to the following: the cube (Plate II. fig. 12.), the rhomboid (fig. 13.), the tetrahedron (fig. 15.), the prism, with three, six, or any number of sides *, (figs. 11 and 16.), the single pyramid, and the double pyramid (fig. 18), which may have any given number of sides. The table (Plate V. fig. 21.) is only a flat prism, and may have more or fewer sides. The rhomboidal dodecahedron (fig. 17.), the pentagonal dodecahedron (fig. 5.) To which Werner adds the lens, the surfaces of which are convex, and the icosahedron. (Plate V. fig. 8.) When the edges at the base of the triangular faces that form the double pyramid, are not placed in a straight line, but form a zigzag, a peculiar form results. (Plate III. fig. 7.) Some mineralogists think these fundamental forms may be conveniently reduced to the prism, the pyra-

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* A prism may have any number of quadrangular sides, or what are called lateral planes. It is terminated by two planes parallel to each other; these are called terminal planes.

mid, the cube and rhomboidal dodecahedron, the regular tetrahedron, and the double pyramid.

F. Do minerals, when crystallized, always take one or other of these forms?

B. They may generally be conveniently referred to one of them, either as perfect, or having undergone some change, by the edges or angles being cut off; and these changes are described as having taken place by truncation, by bevelment, or by acumination.

F. I will thank you to explain the meaning of these terms?

B. By truncation, an angle or an edge is supposed to be cut off. Plate V. fig. 1. represents a cube with each angle and edge truncated, and fig. 7, in the same plate, a cube deeply truncated on the edges. As the truncation is more or less deep, the new face which is formed, will be greater or less, and the truncation may be deeper on one side than another: this modification may give rise to a great variety of forms. But you will obtain a more distinct notion of it, by cutting out models of crystals in wood, or, what is easier, from a potatoe, and afterwards slicing off the corners or the edges; the truncations may be so deep or irregular as nearly to obliterate the original form.

F. I am not to suppose that Nature made perfect crystals, and afterwards cut the parts away?

B. No; it would be more consistent with truth to say, that Nature had been interrupted in the process of crystallization; but this would not be strictly correct. I must again repeat, that by *truncation*, *bevelment*, and *acumination*, we only intend to convey a concise description of the form of crystals, without any reference to their mode of formation.

F. In what respect does bevelment differ from truncation?

B. Bevelment is made on the edges of crystals by two small planes that are inclined, and meet, forming what is called a bevelling edge. Plate V. fig. 32. represents a double six-sided pyramid, with the summits truncated, and the lateral edges rather deeply bevelled. Fig. 11. represents an octahedron, with all the edges bevelled.

F. What is meant by acumination?

B. Acumination is made either on the angles or summits of crystals, by three or more new faces that converge and terminate in a point or wedge; see Plate III. fig. 3[illegible] which represents a four-sided prism acuminated by four triangular faces at each end, but this latter would be more conveniently described as a four-sided prism, terminated at each extremity by two four-sided pyramids. I must now, however, explain to you two terms in constant use in the description of crystals; the *lateral* planes, and the *terminal* planes. The planes are the faces of a crystal, and are sometimes so called. Now if we refer to the figures of the prisms (Plate II. figs. 11 and 16.), the longer faces or planes which, in common language, would be called the sides of the crystal, are the *lateral planes*; and the extremities are called the *terminal planes*; these in common language would be called the ends of the crystal. The longer edges on the sides are called the *lateral edges*, and the shorter ones at the extremities, the *terminal edges*. The new faces produced by truncation, bevelment, or acumination, are called the *truncating planes*, the *bevelling planes*, or the *acuminating planes*.

F. Of what use are these terms in the description of crystals; I will thank you to give a practical explanation of them?

B. If you cut a piece of wood, or a potatoe, into the form of a four-sided prism, the four lateral planes or sides we will suppose to be equal parallelograms, as *a a*, Plate III. fig. 10. Now if you apply your knife parallel to each one of these planes, and cut off four slices diagonally, you will form four acuminating planes, or a four-sided pyramid, as in fig. 30; these acuminating planes are set on the lateral planes. If you take another prism, and cut off slices diagonally from the edges, you will form a crystal (fig. 31.), terminated by four acuminating planes set on the lateral edges, and these planes will be rhomboids. Plate IV. fig. 3. represents a cube acuminated at each angle by three small planes; these acuminating planes are set on the lateral planes. But you will gain a more correct idea of these modifications than any description can convey, by making models of the principal simple form of crystals, and forming acuminating planes on each lateral plane, as in the four-sided prism (Plate III. fig. 30.), or on each alternate lateral edge (Plate V. fig. 30.), &c. In all cases where the figure of the crystal is complex, a drawing or a model will best convey an idea of the true form. Indeed this seems absolutely necessary, when crystals appear to have undergone changes from the united effects of bevelment, truncation, and acumination, which is sometimes the case.

F. What further is to be noticed in the Wernerian description of crystals?

B. The axis of a crystal is a line drawn through the centre to the extremities. In regular prisms, the axis is parallel to the lateral planes, and equi-distant; in the pyramid, the lateral planes converge to the axis. Thus the faces and edges of a crystal may be described as horizontal, vertical, or oblique, with reference to the position of the axis. The angles under which the planes of a crystal meet on these angles of inclination with the axis, are only noticed by the general terms of rectangular, acute, or obtuse, in a greater or less degree, but are not measured by the Wernerian mineralogists. The admeasurement of the angles is of the highest importance in the crystallography of the French mineralogists, as I shall afterwards endeavour to explain to you.

There are also some circumstances to be noticed, with respect to the manner in which crystals occur in nature. Sometimes they are found loose, sometimes they are imbedded in mineral substances of a different species, sometimes they form an incrustation over other minerals, and very frequently they line the cavities of minerals or rocks; they are in such cases said to form *druses.* Crystals are very frequently attached to each other, or aggregated, sometimes in a very confused manner, but in other instances, they are arranged with much apparent regularity. Sometimes two crystals penetrate each other, sometimes they simply adhere at the surfaces. These are called twin, or triple crystals, &c. according to the number that join. Some crystals present the remarkable appearance of having been divided into half, by a section parallel with the axis, and one of the halves appears to have revolved round their common plane of intersection. In some cases, the half which appears to have revolved has passed through only sixty degrees, or one-sixth of the circle; sometimes it has passed through half a circle, and the opposite ends of the halves meet. These crystals are called by Haüy *hemitrope*, or half turned round.

F. I do not well understand the description you have given of the hemitrope crystals.

B. Suppose then two volumes of the same work, bound in a similar manner, to be laid regularly on each other, and to represent one crystal; if you turn the upper volume half round, you will bring the top of the pages even with the bottom of the pages in the other; and the back of one volume will be in a line with the front of the other; the two books which represented a regular crystal before, will now represent a hemitrope crystal.

Crystals which occur in groups or clusters, are sometimes arranged in forms resembling well-known bodies, and are described accordingly. They may be in bundles, or *fascicular*, or diverging like a broom, called *scopiform*. — They may resemble a sheaf, and diverge at both ends, or be *manipular*; — or resemble the leaves of a rose, or be aggregated in rows, or in steps like a stair, &c. — These various forms of the groups arise sometimes from confused crystallization, but sometimes they are nearly regular and peculiar to certain species; I am therefore inclined to refer the arrangement to a general law that I think has hitherto escaped the attention of mineralogists, the existence of which I shall at a future meeting endeavour to prove.

It remains to inform you that there are false or pseudo crystals, as well as real ones.

F. I cannot conjecture what the term false crystal can possibly mean, as I understand by a crystal, a natural body, and not an artificial one, like the paste that imitates the diamond. A false natural crystal appears to me a solecism.

B. A false or pseudo crystal is formed by the infiltration of mineral matter into the cavity which has been occupied by a true crystal that has been decomposed, and has disappeared; or it may be moulded on the surface of a true crystal, and take its form. In the latter case, the crystal may remain as a nucleus, or be decomposed, leaving the false crystal hollow. — These false crystals have not the lustre of real ones, nor have they the same structure. They are in fact, casts or moulds of real crystals, but are often composed of very different mineral matter, from that of the crystal, whose form they have assumed.

F. Of all the characters you have described, which would you select as of the greatest value? I mean which would best enable me to ascertain the nature of the greatest number of minerals?

B. In uncrystallized minerals, the specific gravity or *weight*, and the degree of cohesion or *hardness*; to these we may add the *structure* in numerous minerals that do not occur in regular crystals, yet have a certain arrangement of particles which we may call crystalline. Of the chemical characters, solubility or insolubility in acids, and the degree of fusibility before the blow-pipe. — Where minerals occur crystallized, the form of the crystal, though not so definite a character in the Wernerian method, is still of high value. We may, therefore, without entering on crystallography as the basis of scientific mineralogy, state the essential characters to be, 1st, *weight;* 2d, *hardness;* 3d, *structure;* 4th, *crystalline form;* 5th, *solubility* or *insolubility* in *acids;* and 6th, *degree of fusibility before the blow-pipe.* Many of the other characters may be regarded as accidental, such as colour and transparency, and may vary without changing the nature of the mineral.

F. When I have made myself well acquainted with these characters, and have ascertained the specific gravity of a mineral, by weighing it hydrostatically; the degree of hardness, by rubbing it on some well-known substance, or by trying it with a knife; when I have examined closely its structure, and the form of the crystal; when I have ascertained, by trial, whether it be soluble in acids, or fusible by the blow-pipe; and when I have also noticed the other characters which it may present; how am I to determine from them, to what order, genus, or species, the mineral belongs?

B. This question involves another inquiry, what constitutes orders, genera, or species in minerals? We have seen that the division of minerals into four classes, earthy, saline, inflammable, and metallic, is chemical, and chemistry must form the basis of the other divisions in every scientific system of mineralogy. The orders and genera are, in some respects, arbitrary divisions in mineralogy; but the species may be defined to consist of an assemblage of particles or integrant molecules, having the same constituent parts combined in the same proportion, accompanied with similarity of form in the primitive crystal. We cannot conceive two minerals which have the same form and composition, to belong to two distinct species.

F. If the composition of a mineral is to determine the species, and if minerals that are composed of the same constituent parts and elements, combined in the same proportion, are to be invariably classed together, and receive the same name, of what use can it be, to introduce the crystalline form into your definition of species?

B. In some cases, particularly in the earthy minerals, it is difficult to determine whether certain ingredients which occur in small proportions, are essential constituent parts, or accidental admixtures. The form of the primitive crystal, or its molecule, may in such cases serve to limit the species. If two minerals, supposed to be of the same species, are found not exactly to agree in their analyses, the one containing a small proportion of an ingredient which is not contained in the other, we must refer to the crystalline form, where it can be ascertained. Now, if this be the same in both, we may consider them as belonging to one species, and the redundant principle in the one as an accidental admixture. If the form of the primitive crystal differ, we must regard the redundant principle as an essential constituent part, and class the two minerals as distinct species. Hence it is crystallography, combined with chemistry, that must form the basis of a scientific system of mineralogy. I propose to make this the subject of our next conversation.

CHAP. V.

Crystalline Polarity. — Phenomena of Crystallization illustrative of the Formation of Crystals in the Mineral Kingdom.

F. At our last meeting, you said that Crystallization would be the subject of our next conversation. I have lately seen several crystals so regularly formed, and so perfectly similar to each other, that I could scarcely be convinced they were natural substances, and I feel extremely anxious to learn by what cause this regularity of form is produced?

B. Crystallization, or the property by which the particles of bodies are arranged in regular forms, will perhaps admit of the best explanation, by comparing it with other known properties of matter. All the great masses of matter in the universe have a constant tendency to approach each other; this is called the attraction of gravitation. The particles of every homogeneous body, when brought within a certain small distance, adhere to each other with a greater or less degree of force; this is called the attraction of cohesion. The particles of gold in a guinea, for example, are held together by this cohesive attraction. They may, however, be separated by immerging the gold in certain acids which have a greater attraction for that metal than the particles of gold have for each other. Gold may also be dissolved in quicksilver, owing to the powerful attraction of the particles of the latter metal for those of gold, which is sufficient to overcome their cohesive attraction; this species of attraction is called elective affinity. Beside these three kinds of attraction, there are magnetic and electric attraction, peculiar to certain bodies. — A magnet, it is well known, attracts iron, and communicates to it the magnetic property of attracting other pieces or bars of iron. — The magnet has also two points called poles, and if it be freely suspended, these poles will turn towards the north and south poles of the earth; and if two magnets, so suspended, be brought near each other, the north pole of the one will repel the north pole of the other, and attract the south pole; this is called magnetic polarity. If a magnet be broken into a number of pieces, each small piece has also its north and south pole, and possesses all the properties of the magnet from which it was broken. The earth, and probably all the planets, have magnetic polarity. Electric attraction is excited in certain bodies by friction, or by heat, and, like magnetic polarity, is of two kinds, that attract and repel each other; these two kinds of electricity have been called positive and negative. Some crystals, when heated, become electric, and the electricity at the opposite extremity is always in the two opposite states. Of these different kinds of attraction, that of magnetism, combined with magnetic polarity, appears to offer the best illustration of crystallization; for neither the attraction of gravitation nor of cohesion can produce the symmetrical forms of crystals, and elective affinity will not apply, as all the integrant particles of each perfect crystal are homogeneous.

F. Is it possible that magnetism can afford any illustration of the cause of crystallization?

B. Were we to suppose a number of minute magnets, each having a north and a south pole, to be floating in free space, or in any fluid which permitted them to move freely (see Plate I. fig. 1.); if from the evaporation of the fluid, or any other cause, these minute magnets were brought nearer to each other, so as to be within the limits of their polar attractions, the north pole of the one would turn towards the south pole of the other, and thus a number of regular figures might be produced, either quadrilateral or triangular (see Plate I. fig. 2.) If the magnets are conceived to be indefinitely small, the intermediate vacuity will, as far as relates to our senses, entirely disappear. Now, if instead of magnetic polarity, which is confined to ferruginous minerals, we suppose the molecules of any other mineral to have attracting and repelling points or poles, and these molecules were held in solution; on being brought nearer to each other, the opposite poles of each would, in like manner, be attracted, and form regular figures, resulting from the polar attractions, which may therefore be properly called crystalline polarity.

F. Is it necessary to suppose that the elementary particles of bodies have any other shape than a spherical one, which is the simplest of all forms?

B. Every plane geometric solid may be formed of a number of spheres; for if these be indefinitely small, each side will present to the eye a plane surface, the inequalities produced by the convexity of the spheres being too small to be visible.* Pyramids formed of cannon-balls, when viewed at a distance, appear to have plane regular surfaces. If we conceive a number of small spheres to have, at opposite points, two, four, or six attracting and repelling poles, the polar axes being situated either rectangularly or obliquely with respect to each other, we may construct

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* It was shown by Sir Isaac Newton, that the rays of light are reflected by a repulsive power which acts at a small distance from the surfaces of bodies. It is owing to this cause that light is reflected in parallel lines from a plane metallic speculum; for if we view a polished speculum with a microscope, it presents ridges and furrows like a ploughed field, which would throw the light in every direction, did it really impinge on the surface before it were reflected.

in idea a series of regular figures. Three would form the base of a triangular prism (fig. 3.) If we placed one sphere upon these, it would form a tetrahedron; four spheres placed horizontally would form a square (fig. 4.); and four more placed on these would form a cube.

If the polar axis in each sphere were placed obliquely, we should have a rhomboid (fig. 5.); or seven spheres would form the base of a hexahedral prism (fig. 6.) *

F. I perceive that magnetic polarity may serve to illustrate the action of polarity in other bodies; but the illustration is merely analogical; you do not suppose that crystalline polarity and magnetic polarity are modifications of the same power?

B. It is not improbable future discoveries may prove that chemical attraction, electricity, magnetism, and crystalline polarity, are intimately connected and dependent on one general law. The connection between chemical and electrical attraction has been already shown by

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* In the year 1811, Mr. John Dalton, of Manchester, suggested to the author the possible construction of Haüy's primitive crystals and integrant molecules from spherical atoms, a mode of formation in accordance with the atomic theory of that eminent chemical philosopher. Before the year 1790, the writer of the present volume, in a letter to his early friend and fellow-townsman, Dr. Wilkinson, now of Bath, stated his opinion at length (accompanied with an explanatory drawing), that the expansion of water in freezing was owing to the polarity of the particles which arranged them in regular groups or crystals, leaving interstices between each.

Sir H. Davy, in a series of the most interesting experiments that the whole range of chemical philosophy presents. From these experiments it appears, that bodies which have an elective affinity for each other are always in opposite states of electricity, the one being negative, and the other positive; and it is even possible to destroy or change for a time the strongest elective affinity of bodies, by changing their state of electricity. I must, however, confine my observation to certain phenomena presented to our notice in the crystallization of salts or metals, which are illustrative of the formation of crystals in the mineral kingdom; but on this subject I shall be brief, as I presume you are already acquainted with the leading principles of chemistry.

F. I will thank you, however, to state the principal facts which elucidate the formation of crystals.

B. It is well known to the chemist, that for the formation of perfect crystals in the laboratory, certain conditions are required.

1st. The particles or molecules of bodies must be separated from each other, so as to allow of free motion, and this separation is effected by the action of caloric, or by solution either in a liquid or aëriform fluid.

2d. The cause by which the molecules were separated, must gradually diminish in intensity or in quantity, so as to permit the molecules to approach and arrange themselves freely, according to their crystalline polarity. If this be not the case, a confused crystallization will take place.

F. I will thank you for a more full explanation of these conditions.

B. A metal may be dissolved or melted by caloric so as to admit a free motion of its parts; if the action of caloric be gradually diminished, or, in other words, if the metal be permitted to cool slowly, the mass will become crystallized. It is, however, only some of the metals that can thus be reduced to a crystalline form in our laboratories; but what can be effected in this way in a few hours, is sufficient to convince us, that in the great laboratory of nature, with time as one of the elements, the most perfect metallic crystals may be formed by the agency of heat.

The second case, or that of solution in liquids, may be elucidated by the action of water on common salt; the particles of water having a greater attraction for those of the salt, than the particles of the latter have for each other; the particles of salt detach themselves and unite with those of the water, and become suspended in it. When the water is diminished in quantity by slow evaporation, the particles of salt, being brought gradually nearer to each other, unite by the combined action of attraction and crystalline polarity, and form cubes.

The third case admits of a similar mode of explanation; for, when a mineral is volatized or rendered aëriform by the action of caloric, as the latter gradually diminishes, the molecules are brought nearer together and compose crystals; in this manner, the crystals lining the craters of volcanoes are formed. The volcanic fire, which ceases to act on the surface, silently emits mineral exhalations, that cool and crystallize on the projecting rocks within the crater. Of these cases, that of solution in liquids is most within the power of the chemist to imitate, though this is also, strictly speaking, a solution by caloric, as the liquid itself only preserves its fluidity by the agency of caloric, and becomes solid when the temperature is reduced, as in the well-known instance of water and ice.

F. What facts, respecting crystallization from liquid solutions, appear most deserving the attention of the crystallographer?

B. 1st. Each species of salt has a peculiar crystalline form, which form, however, may be varied by certain causes.

2d. The angles and edges of crystals appear to form first, and are also the first to dissolve when a saline crystal is immerged in water.

3d. The crystals which form at the bottom of a deep vessel, are larger than those which form near the top.

4th. When several salts are in solution in the same liquid, it appears, that without any chemical combination with each other, they exert a mutual influence in changing the crystalline forms of each. Thus, for example, common salt which crystallizes in cubes from a pure solution, takes a form approaching to the octahedron, called the cubo-octahedral, when it crystallizes from a solution containing borax or boracic acid.

5th. The crystallization of a salt may take place in a solution which has a strong gelatinous consistence. The crystals do not envelope any portion of the jelly, and do not undergo any variation of form, but are almost always isolated, and have a remarkable regularity and symmetry of the parts. This fact, stated by M. S. Beudant, in the Annales des Mines, 1818, appears to throw considerable light on the crystallization of minerals. The change of the crystalline form by the presence of other crystals in the solution is also deserving of more attention than it has yet received, as it appears to illustrate the cause of that variety of crystalline forms which the same species of mineral sometimes presents.

F. I will thank you to inform me how the two last cases appear to illustrate the formation of natural crystals?

B. As it is an undoubted fact that the same species of mineral often presents a variety of crystalline forms, which, though very different from each other, are perfect, and as the integrant particles or molecules must be supposed to have the same form in each one of these crystals, there must have been some cause to change the arrangement of the molecules, and give rise to the diversity of form, of which we have been speaking. Thus, crystallized carbonate of lime, or calcareous spar, occurs in the form of a rhomb, or a six-sided prism, or a dodecahedron with triangular faces. Sulphuret of lead, or galina, is sometimes crystallized in cubes, and sometimes in octahedrons. Now, it is well known that crystals of the same species of mineral often occur imbedded in very different kinds of rocks, or are associated with other minerals. This different kind of mineral matter, which serves as the *gangue* or *matrix*, must have been present when the crystal was in a state of solution, whether by caloric or by water; and it must have had the same influence on the formation of the crystal, as the mixture of different salts in a saline solution. A minute portion of the *gangue* or matrix, or of the associated minerals, may also become enveloped in the crystal, and occasion that difference in the result of chemical analysis which has so frequently perplexed the ablest chemists. On this account, it would be desirable that chemists should state the crystalline form of the mineral they submit to analysis; and, if possible, the nature of the rock, or vein in which it was imbedded, and the minerals with which it was associated.

The case of crystallization taking place in a solution which has a gelatinous consistence, proves that the action of crystalline polarity has considerable force, so as to overcome the tenacity of the solution; and as this tenacity is sufficiently strong to prevent the crystals from touching each other, they assume a more distinct and perfect form. This is analogous to what we may frequently observe in lavas, and a variety of porphyritic rocks allied to lava, in which different crystals are most distinctly formed. Now we cannot doubt that these lavas have been for a long time in a semifluid tenacious state, which permitted the molecules of the different minerals to arrange themselves with great regularity, for we no where observe crystals formed more symmetrically than in the midst of volcanic rocks. The idea that the crystals were ready formed, and were afterwards licked up by the lava, is so extremely unphilosophical and absurd, it may well excite our astonishment that it could ever have been seriously maintained.*

Many crystals appear distinctly to be composed

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* Many of the minerals that occur perfectly crystallized in lava, and which were long supposed to be foreign substances, must now be regarded as essential parts of lava, for the observations of Cordier prove that the lava itself is entirely

of thin plates or laminæ, which may be separated from each other, leaving a smooth shining face where the plate has been struck off. This separation of the laminæ takes place either on the sides, the edges, or the angles of crystals, and is called by lapidaries the cleavage. In some crystals, the laminæ are separable in two directions; in other crystals, in three or four directions, or even more. Such minerals are said to have a twofold, a threefold, or a fourfold cleavage, as I have before mentioned. The inclination of the laminæ, or the angle under which they meet each other, requires to be accurately measured to ascertain the primitive form and the structure of crystals. To obtain a more clear idea of this, suppose the leaves of a book to represent the laminæ of a crystal. If the book be partly opened, the leaves on each side will represent the laminæ of two sides of a crystal inclined to each other, and the degree of the opening will represent the angle of inclination

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composed of the same minerals confusedly crystallized and aggregated. From a large mass of bituminous shale which had become ignited and fused at the coal-pits near Newcastle-upon-Tyne, I have seen a specimen in which small crystals, apparently of felspar, were formed. The formation of white opaque crystals in the midst of a mass of green glass is not very uncommon, where the glass has remained a long time in the furnace, and cooled slowly.

under which the laminæ or faces of the crystal meet. It is obvious that this may be either rectangular, oblique, or obtuse, and that the degree of inclination admits of measurement.* Each leaf representing a single lamina, the partings of the leaves will represent the joints or cleavages. The direction of these cleavages is obviously that of the leaves themselves.

Now, if we suppose a crystal either a rhomb or a cube, or any other parallelopiped, to be only divisible by laminæ parallel to each of the sides, though we may, by separating the laminæ, reduce the size of the crystal, we shall not change its form. When this is the case, the form of the crystal is said to be the primitive one, as it is not changed by any further division. If, on the contrary, the laminæ are only separable on the angles, the form of the crystal will undergo a complete change by the cleavage; for instance, if we take a cube of fluor spar (Plate II. fig. 1.) we may, by a well-managed stroke, cut off each of the eight solid angles of the cube *a*, *b*, *c*, *d*, and in their place we shall have smooth triangular faces, *e*, *f*, *h*, &c. If we continue to cut off laminæ parallel to each of these faces, we shall change the form of the crystal entirely, for the faces of the cube will disappear; the

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* The goniometer, an instrument for measuring the angles of crystals, is described in the 7th chapter.

new faces will be triangular, and we shall obtain a regular octahedron (fig. 2.) If we continue to cut off laminæ parallel to each of the faces of this octahedron we may diminish its bulk, but we shall not change its form. Were we to try to restore the original cubic form by striking off the angles of the octahedron, we could not succeed, but should only obtain rough and irregular fractures, without approaching the form of a cube.* This octahedron therefore is the primitive form of fluor spar, being divisible in a direction parallel to each of its sides, without changing its form.

F. Then the cube is not the true form of the crystal of fluor spar, but an accidental arrangement of the molecules ?

B. Though the cube is not the primitive from of fluor spar, it cannot be called an accidental form, being the result of a regular law, as I shall afterwards explain.

F. Are the primitive forms of minerals numerous ?

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* The reason why crystallized minerals will only cleave with polished faces in the direction of the laminæ, will be obvious from the structure of the cube (Plate II. fig. 7.), the joints being in the direction *a*, *b*, *a*, *l*, and *a*, *c*, it will split regularly in these directions; whereas, were we to attempt a separation along the diagonal *b*, *c*, it could not be effected without displacing the molecules on each side of the line *b*, *c*, and producing an uneven surface.

B. No; they are reducible to six.

1st. The parallelopiped (Plate II. fig. 13.), which includes the cube, the rhomb, and all other solids, contained under six faces, the two opposite faces being always equal and parallel.

2d. An octahedron with triangular faces (fig. 14.)

3d. The regular tetrahedron (fig. 15.)

4th. A regular hexahedral prism (fig. 16.)

5th. A dodecahedron, with rhomboidal faces (fig. 17.) And,

6th. A dodecahedron, with triangular faces (fig. 18.)

F. If the number of primitive forms be so limited, many different species of minerals must have the same primitive form?

B. This is sometimes the case where the primitive form is a regular one that does not admit of variation, in the proportion of the sides or angles, as in the cube, the regular tetrahedron, and the regular hexahedral prism; but the rhomb may vary in its angles in different species, and the pyramids of the octahedron may be more or less acute, and they may have rectangular or rhomboidal bases, and the proportion between the base and the height may vary indefinitely in all parallelopipeds, except the cube and regular rhomb.

F. Do some of these primitive forms more frequently occur than others?

B. Yes; the parallelopiped and the octahedron are the most common. The six-sided prism occurs frequently, but the tetrahedron and dodecahedrons occur very rarely. It is also deserving notice, that the same form is sometimes primitive in one species and secondary in another, as we have seen in the fluor spar, which has the cube for one of its secondary forms.

F. Then all the apparently infinite variety of complex crystalline forms that occur in the mineral kingdoms, are reducible to the above six simple forms?

B. They are either reducible to one or other of these forms by mechanical division; or from the direction of the joints, we may infer, that such would be the primitive form, if the cleavage could be effected.

F. How can we be certain that we have obtained the primitive form?

B. When we find that the crystal can be divided in directions parallel to each of its sides, without changing its form, we may then be certain that we have obtained the primitive form.

F. Are the molecules or particles of the crystal of the same form as the primitive crystal?

B. In all crystals which have parallelopipeds for the primitive form, we must suppose this to be the case. Let the cube (Plate II. fig. 7.)

represent a primitive crystal, if it be divisible in a direction parallel to its sides, the result will be, the formation of a number of smaller cubes; and, however far we carry this division in imagination, we shall only obtain smaller and smaller cubes, which we may suppose to represent the integrant molecule. But when the primitive form is not a parallelopiped, the form of the molecule may vary from that of the primitive crystal. If, for instance, Plate II. fig. 6. represents the base of a regular hexahedral prism, which we may suppose to be a primitive crystal divisible in a direction parallel to all its sides *a*, *b*, *c*, *d*, *e*, *f*, the different sections, crossing each other diagonally, will form equilateral triangles, and by continuing the divisions ever so far, the result will be the same; we shall diminish the triangles without changing their shape; these triangles may, therefore, be regarded as the basis of so many triangular prisms, which are the integrant molecules. In some instances, when the primitive crystal is a rhomb, or any other parallelopiped, as represented Plate II. fig. 19. this primitive form, besides being divisible in directions parallel to its sides, admits of a further division by a plane passing through the diagonal *a*, *b*, which forms two triangular prisms; each of these may be further divided in directions parallel to its sides, and these divisions will form triangular prisms, which must therefore be regarded as the form of the integrant molecule.*

F. How many forms of the integrant molecule are known?

B. Not more than three, and these are the simplest which can exist in plane solids; namely, the tetrahedron (Plate II. fig. 10.), the three-sided prism (fig. 11.), and the parallelopiped (fig. 12.) I have said they are the simplest solid plane figures, because they are bounded by four, five, and six plane surfaces. These forms may vary in their dimensions, and the proportions of their angles.

F. Can we ever obtain the integrant molecules by mechanical division?

B. The integrant molecules or particles of bodies are indefinitely small, even though they may be composed of two or more atoms of different substances, as in salts. The molecules of the latter may be separated from each other by solution, but we have no means of effecting this

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* It would be more consonant with other parts of Haüy's theory, and at the same time make the theory less complex, to regard the triangular prism as the true primitive form of the crystal in both these cases. The triangular prism may be obtained by three cleavages from the hexahedral prism, as represented by the shaded part x in fig. 6.

Indeed, in all instances, where mechanical division would produce different forms from those which have been regarded as primary, it would be more correct, I conceive, to consider the ultimate form resulting from such division as the primary one.

separation mechanically, or of ascertaining the real magnitude of a molecule of salt, or of any mineral species; still, however, by mechanical division, we ascertain what would be their form, if it were practicable to separate and perceive them, as I have explained with respect to the six-sided prism.

F. How are we to discover the direction in which the laminæ of crystals are arranged, in order to effect their mechanical separation?

B. In some minerals, the joints or cleavages which show the direction of the laminæ are very obvious; in others, they may be made apparent by heating the crystal; and in many instances where the joints seem concealed, they may be discovered by examining the crystal between the eye and the light of a candle; the reflection from the interior laminæ will show the direction of these joints. The joints in one direction are, however, frequently more perceptible than in another.

F. How is the mechanical division effected?

B. Sometimes by the pressure of a sharp instrument, as a knife or file, applied to the natural joints, and sometimes by a gentle stroke with a small hammer on the back of the instrument. When an edge or angle is to be removed, a delicate percussion will often be sufficient. Where the separation is effected with difficulty, as in some brittle minerals, heating the mineral red hot, and plunging it in water, will produce fissures in the direction of the joints. All crystallized minerals may, therefore, be described as composed of plates or laminæ formed of the integrant molecules; though, as I shall afterwards show, this is only a convenient mode of explaining their structure. I propose, in our next conversation, to explain Haüy's theory of crystallization, showing how an almost endless variety of complex secondary forms may be the result of a few simple laws; I shall afterwards state the method he has invented of denoting, by symbols, in a very concise manner, the laws which produce these forms, and furnish you with his nomenclature of crystals. When you are more fully acquainted with the subject, I shall endeavour to give as clear an explanation as I am able of the application of geometry to crystallography. (See Book VI.)

CHAP. VI.

Theory of the Structure of Crystals. — On Crystallography.—Objections to the Theory stated.[*]

B. I SHALL now endeavour to explain what have been denominated the *laws of decrement*, according to which, all crystals that differ from the primitive crystals, appear to have been formed.

F. What is the meaning of the term decrement in crystallography?

B. According to the theory of Haüy, crystals are supposed to grow or increase by the application of plates or laminæ to their faces, composed of ranges of molecules. — Now this increase may take place in three different ways.— First, each side of the crystal may be regularly covered by laminæ constantly increasing, so as to envelope the whole primitive nucleus.

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[*] Those readers who are only desirous of learning the natural history and character of minerals may, for the present, pass on to Chap. VIII. and defer the reading of Chap. VI. and VII. until they have obtained some knowledge of crystallized minerals. — Brongniart has well observed of crystallography, " Quelque soin que l'on mette à rendre l'expression clair, il est très-difficile qu'elle soit bien comprise à une première lecture, par quelque'un qui n'a jamais vu avec attention des cristaux." *Traité Elémentaire de Minéralogie.*

In this case, the primitive crystal will increase in size without changing its form. Secondly, a number of laminæ, equal in size to the faces of the primitive crystal, may be applied to each face. If the primitive crystal were a cube, each side, being thus lengthened, would form a double cross composed of three prisms intersecting each other. This is a case which does not occur.* Thirdly, new laminæ might be added to the sides, each of which decreased by one or more ranges of molecules on the edges or angles. This will change the form of the crystal, and produce what is called a secondary crystal. It is the last of these cases that we have to consider. Let us suppose a cubic nucleus (Plate I. fig. 8.) to be composed of seven plates, each containing forty-nine molecules, or seven in length and breadth; let another plate, decreasing by one range of molecules, all round, be laid upon the upper face of the nucleus, this will contain five molecules on each side. A second plate, decreasing by one range, will contain three molecules on each side, and the third plate, by a similar decrease all round, will consist of only

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* If we suppose the four opposite sides of the cube to be lengthened, while the other two remain stationary, they would make a single cross, formed of two prisms at right angles to each other (Plate I. fig. 7.), the junction of these prisms would form four inner or *re-entering angles, c. c. c. c.*; but it is observed that no *re-entering angles* occur in regular crystals.

one molecule : — thus we shall form a series of pyramidal steps on the upper face of the cube, by a progressive decrement of one range of molecules on each of the successive plates.

F. Then by a decrement is meant a diminution of the laminæ that are applied to the faces of the primitive crystal.

B. This is the precise meaning of the term. The Count de Bournon, in his *Traité de Minéneralogie*, proposes to substitute *reculement*, or retiring, in place of decrement; but the former is sufficiently definite. — Decrements may take place in different directions, and are of four kinds, which I shall proceed to explain. They are called decrements on the edges, decrements on the angles, mixed decrements, and intermediate decrements.

F. I will thank you to explain these terms.

B. In decrements on the edges, the laminæ decrease by one or more rows in a direction parallel to the edges of the primitive crystal. In decrements on the angles, the laminæ decrease by one or more rows in the direction of the diagonal, or from one angle to the opposite one. These two are by far the most common cases of decrement, and I shall proceed to explain them, and reserve the explanation of the mixed and intermediate decrements, until you have obtained a clear notion of the former.

F. I will thank you to state one of the simplest cases of the formation of a secondary crystal by decrements on the edges.

B. The pyramid formed on the cube (Plate I. fig. 8.) may be called the simplest case of decrement by one range on the edges, but it has not been sufficiently illustrated. We will therefore substitute a larger cube (Plate II. fig. 3.), each side containing seventeen molecules in length; *a, b, f,* represents one face of the cube uncovered. Now if we suppose a series of eight laminæ, (each decreasing by one row in breadth all round,) placed on the upper face of the cube *a, b, c,* (leaving the other parts of the figure for the present out of consideration,) we shall form four inclined faces, terminating in the point *d z*; in other words there will be a four-sided pyramid formed on the upper face of the cube. This pyramid is formed by what is called a decrement of one row in breadth, and were a similar decrement to take place on the lower side of the cube, we should have a secondary crystal, composed of a low four-sided prism, terminated by two four-sided pyramids.

F. I observe that this pyramid is formed by a series of ascending steps, but the faces of pyramids in crystals are smooth.

B. If, instead of eight laminæ, we suppose there are a greater number, each decreasing, by one row in breadth, the inclination of the faces of the pyramid will remain the same; but the thickness of each edge being diminished, will become less perceptible. Were each of the laminæ not thicker than a sheet of writing paper, the faces of the pyramids would be nearly smooth; and if they were one hundred times thinner than the paper, they would appear quite smooth.

F. Can forms of greater complexity than the pyramid result from a similar decrement of one range on all the edges?

B. Yes; the rhomboidal dodecahedron (Plate II. fig. 17.) may be formed by a similar decrement taking place on all the edges of the cube. We have before stated that this cube (fig. 3.) is formed of 17 square laminæ, having 17 molecules in length and breadth, or 289 molecules in each square, the whole cube will consist of 4,913 of these molecules. Let a series of plates be applied to each face of the cube, each diminishing by one row in breadth all around, the first plate will contain 15 molecules in length and breadth, or 225 in the whole. The second plate will contain 13 molecules on the edges, and form a square of 169 molecules; the third will contain 111, and the number of molecules in the succeeding plates will *be* 91, 49, 25, 9, and 1, as each succeeding plate will be equal to 11, 9, 7, 5, 3, and 1 molecules in length and breadth, (see fig. 3.) Thus there is raised a four-sided pyramid on each of the six faces of the cube. Instead, however, of having 24 faces, the two triangular faces which unite at each edge of the cube, will be in the same plane, and form one rhombic face; we shall therefore have twelve rhombic faces, or, in other words, a rhomboidal dodecahedron. Here then we have a secondary crystal enveloping the cube; and it is worthy of remark, that the faces being formed of the edges of the molecules, will not present so brilliant a lustre, as that of the nucleus which is formed of the faces of the molecules. To obtain the primitive nucleus, we should begin to cut off the solid angle *d*, for instance, in a direction parallel to *b*, *c*, or the short diagonal of the rhombic face, and so with the rest, taking off successive layers until we arrive at the cubic nucleus *a*, *b*, *f*, *g*, *c*.

F. In the formation of this crystal, I am surprised at the conversion of the twenty-four triangular faces of the pyramid, into twelve rhomboidal faces.

B. This is the necessary result of a general law *, for where decrements take place by one range on the two sides of the same edge or angle, the two new faces formed will be in the

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* An inspection of Plate I. fig. 8. will make it obvious, that a decrement of one range on the face *b* of the cubic nucleus, will raise another similar pyramid on that face, and that the faces of both pyramids would coincide with the dotted line *c c*, or be in one plane. The same result may be conceived to take place on each side of the cube.

same plane: I shall afterwards explain this more fully. Had the decrement in the above instance taken place by two ranges in breadth, the pyramids would have been shorter and more inclined, and would have formed twenty-four faces. Had the decrements taken place by one row in breadth and two in height, the pyramids would have been longer or more acute, and would have also formed twenty-four triangular faces.

F. What is the precise meaning of decrements in breadth and decrements in height?

B. Decrement in breadth is used, when the thickness of the plate of superposition is only equal to one integrant molecule, but either one, two, or more rows of molecules may be abstracted, and in like manner from each succeeding plate; in this case we say, the decrement takes place by one, two, or more rows in breadth. *Decrement in height* is used, when the plates diminish by only one row of molecules in breadth, but each plate may be the thickness or height of two or more molecules; we then say, the decrement takes place by two or more rows in height.

F. Do these two kinds of decrement ever take place in the same crystal?

B. Yes; I will state an instance from M. Haüy, of two kinds of decrement on the faces of the cube, one a decrement of two rows in breadth, the other of two rows in height; these two decrements on the cube produce a secondary crystal, which is a dodecahedron with pentagonal faces, (see Plate II. fig. 5.*) By the inspection of the figure, it will be seen, that a kind of wedge is formed on each face of the cube instead of the four-sided pyramid, as in fig. 3. The edge of the wedge, or *a b*, forms one side of the pentagonal face, *a b*, *b d*, *d f*, *f c*, *c d*. The decrements are conceived to take place by two ranges in breadth on the upper face from *c d* to *a b*, and in the same manner on the opposite face. But on the lateral face from *c d* to *f*, the decrements take place by two ranges in height, and in the same manner on the opposite face.

F. These faces, I observe, are all equal, and are irregular pentagons ; but I am greatly surprised, that the decrement of two ranges in height on one side of the cube should form a face which coincides with the face formed by a decrement of two in breadth on the other side.

B. This is the necessary result of certain rules of *proportion*, which will be easily understood by those who are acquainted with the

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* By forming a four-sided prism from a potatoe, and cutting off two of the opposite upper edges at an angle of about forty-five degrees, and the other two at a more inclined angle, or about thirty degrees, the prism will terminate in a wedge. The edge of each wedge forms one edge of each of the pentagons in the crystal we are now considering, and there are six wedges, as will be evident from Plate II. fig. 5.

elements of geometry, as I shall afterwards explain to you. In the mean time, if you trace the decrements from *f* to *a b*, without any reference to the sides of the nucleus, you will see that the ranges ascend by a regular series of steps, each of which is two molecules in breadth and one in height; so that if we regard the decrements as continued from *a b* to *f*, they are of one kind, though it is in reality a decrement of two in breadth, on one side of the cube, and two in height on the other. I shall now proceed to give you two cases of decrement on the edges of the rhomb.

The first, by one row in breadth, which forms a regular six-sided prism (Plate I. fig. 9.)

The second, by two rows, which forms a dodecahedron, with triangular faces (Plate III. fig. 7.)

To exemplify the first, let E, O, I, K, Plate I. fig. 9. represent the three edges of a primitive rhomb, and O, A′, I, K, one of its three lower faces. Let A A′ represent the direction of the supposed axis of the rhomb, passing through its obtuse summits. Now let a series of laminæ, equal to the face of the rhomb, be applied to the three upper faces of the nucleus, each retiring one range on the lower edges. By this decrement of one range, the new faces formed on each of the six edges of the rhomb, will be perpendicular to the axis A A′, and as there will be six of these planes, a six-sided prism will be formed, as represented fig. 9.; it will be terminated at each extremity by three rhombic faces, three of which, *a*, *b*, *c*, are seen in the above figure; they are parallel to the corresponding faces of the primitive nucleus. The lower face *a* in this figure is supposed to be that of the nucleus itself. The laminæ, which are placed on the rhomb, are each of the same size as the faces of the rhomb, because though they decrease by one range on the lower edges, they increase by one range on the upper, in order to envelope that part of the rhomb; for it is a general law, that the laminæ increase on those sides where the decrement does not take place.

The dodecahedron with scalene triangular faces (Plate III. fig. 6.) is formed by a decrement of two ranges in breadth, on six edges of the primitive rhomboid of calcareous spar (see fig. 7.) E O, O I, I K, represent three of these edges, and A A′ the obtuse angles of the rhomb. In Plate I. fig. 10. three of the edges of the rhombic nucleus from which the decrements commence are represented as E O, O I, I K. The laminæ as they are successively applied to the rhomb increase its length in the direction of the axis from A to *s* (Plate I. fig. 10.), until they terminate in the summit *s*′. The same effect may easily be conceived to take place by a similar law of decrement extending downwards from the same edges, until they terminate in the lower apex S. (Plate III. fig. 7.) Though the decrement takes place by two ranges on the six edges E O, O I, &c. yet no decrement takes place on the vertical edges A E, A I, A G. On the contrary, there is an increase of one row on each, in order to envelope those parts of the crystal. Thus the rhombic face of the nucleus contains 64 small rhombs, and the plate immediately above it contains 49 small rhombs; whereas had there not been an increase of one range on the upper edge it would only have contained 36 rhombs. The line E *s* represents the edge of this pyramid such as it appears to the eye, and E *s'* such as it really exists; but the distance *s s'* is not perceptible, in consequence of the extreme minuteness of the size of the molecules. The same reason prevents the channels of the steps, (as represented in the figure,) from being sensible in the natural crystal, though in some cases these channels are perceptible.

F. Does this crystalline form frequently occur in the mineral kingdom?

B. Yes; calcareous spar in this form is very frequent in the mines in the vicinity of Matlock in Derbyshire, and is provincially called dog-tooth spar. M. Haüy has given to this form of the crystal the name metastatic. There are also other decrements which form crystals nearly similar.

F. If similar forms may result from different laws of decrement, the science of crystallography appears beset with difficulties that are not easy to surmount.

B. By the aid of geometry we are enabled to discover what will be the form of any secondary crystal. If the form of the primitive crystal, together with that of the integrant molecule, and the law of decrement be known, we can thus complete in theory the form of the crystal, without ever having seen it in nature, as I shall afterwards show you.

F. Can the structure of the two last secondary forms, be rendered more intelligible by models?

B. Yes; if you have a model of the primitive rhomb cut in wood, we will suppose it to be placed in the same direction as in Plate III. fig. 8. or Plate I. figs. 9 and 10. *viz.* with the obtuse summit vertically. Let a thick card be cut into three similar rhombic faces, as represented in Plate I. fig. 11. If the edges *b*, *b*, be glued together, it will form a cap that will fit the three upper faces of the model, and will cover them, excepting a small space round the edges, which will be equal to the thickness of the card; this will represent a decrement of one range in breadth. A series of these caps placed over each other, will represent so many crystalline laminæ covering the rhomb, and will form a prism, as represented Plate I. fig. 9. If a series of caps, instead of having faces of the same size as the model, progressively decrease on the lower edges, as represented fig. 10., they will terminate in a pyramid. I must proceed to explain some cases of decrements on the angles.

F. These I suppose will be more difficult to understand than the decrements on the edges.

B. After you have obtained a clear idea of the decrements on the edges, those on the angles may be rendered very intelligible, with some attention to the subject. The simplest case that can be cited is a decrement of one range on all the angles of the cube, producing a regular octahedron. This arrangement is represented Plate II. fig. 4. ; part of the cubic nucleus *h*, *i*, *f*, is seen uncovered. In decrements on the angles, the cubic molecules are abstracted in the direction of the diagonal, or the lines *c*, *b*, *c*, *l*, of the cubic nucleus, (fig. 7.) and the angles of the molecules form the new faces, as seen in fig. 4. By a decrement of one molecule *c*, 1, (fig. 7.) the angles of the molecules marked 2, 2, form the edge of the first plate on which the decrement is made; and the angles of the molecules 3, 3, 3, form the edges of the second plate, each plate decreasing by half the diagonal of the molecule. If a similar decrement of one range be made on all the three faces of the solid angle *h*, (fig. 4.), three trapezoidal faces will be formed, of which *h* will be the centre, and these three faces, being each in the same plane, will coincide and form one triangular face, as represented fig. 8., where *h* corresponds with the solid angle of the cube from which the decrement set out, and *a*, *b*, *c*, are the new faces that unite to form the equilateral triangle that constitutes one face of the regular octahedron or secondary crystal formed on the cube.

F. If I understand you rightly, the points or solid angles of the molecules, form the faces of secondary crystals in decrements on the angles; whereas on decrements in the edges, the faces are formed by the edges of the laminæ; now if this be so, we ought to see the face studded with sharp points in the one case, and in the other, the face should present parallel striæ or steps.

B. Had we a microscope sufficiently powerful to render the molecules visible, this arrangement would be apparent. In some secondary crystals, the striæ are sufficiently distinct to mark the direction of the laminæ.

F. Are there many varieties of secondary crystals, formed by a decrement of one range on the angles?

B. Yes. The decrement of one range, for instance, on the solid angles of the octahedron, forms a cube; the six angles of the octahedron are placed in the middle of each of the cubic faces.

(See Plate II. fig. 2.) A decrement of two ranges on the six lateral angles of the rhomboid, forms a six-sided prism. It has before been shown, that a decrement of one range on the edges also forms a six-sided prism; both these forms take place in calcareous spar.* Plate III. fig. 6. represents the prism with the primitive rhombic nucleus. To extract this nucleus, we must cut off three of the upper alternate edges of the prism 1, 3, 5, by oblique sections on each, as represented in fig. 3.; and make three similar sections on the lower edges 2, 4, 6; each of these faces will have a polish and lustre, which show that they coincide with the natural joints or cleavage of the prism. It would be impossible to divide the prism in any other directions.

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* A decrement on the angles of two rows in breadth, is equal to one diagonal of a molecule, for in decrements on the angles the distance between the edges of the laminæ of superposition is equal to as many semi-diagonals of a molecule as there are ranges taken away, but in decrements on the edges the distance of the laminæ is equal to the breadth of as many molecules as there are ranges abstracted. Thus in Plate II. fig. 9. if a decrement of one molecule commence on the angle A, the first plate will have its edge parallel to line 1, which is half the diagonal. The edge of the new plate being formed by the angles of the molecules *a. a.* a decrement of two ranges will make the edge of the plate parallel to line 2, equal to one diagonal. The edge of this plate is formed by the angles of the molecules *b. b. b.*

When the bases of the prism disappear, as in fig. 4., it will be terminated at each end by three pentagonal faces. Continuing the sections parallel to these faces, the sides of the prism are diminished, and at length form small triangles, as in fig. 5. As new sections are made, these triangles disappear, and we obtain the primitive nucleus A, E, I, O, fig. 6. By forming a six-sided prism from a potatoe, and cutting off the alternate edges of each terminal plane as here described, the result will be the formation of a rhomb, which may be supposed to represent the primitive nucleus.

F. As the most common laws of decrement, are those which take place on the angles, and edges, it does not appear obvious, that many complex forms can result from laws so extremely simple.

B. The novelty of the subject may prevent you from perceiving this at first, but on mature consideration, it will appear far more surprising, that these laws do not produce a greater variety of forms than have hitherto been observed in the mineral kingdom; and this would be the case, did not Nature act with the greatest simplicity, and were the number of ranges abstracted extremely variable. " If, for example," says M. Haüy, " there were decrements of twenty, thirty, or forty, or a greater number of ranges of molecules, as may easily be conceived to take place; the multitude of forms that might then exist in each mineral species, would be sufficient to confound the imagination, and the study of crystallography would present an immense labyrinth, in which, even assisted by theory, it would be difficult to trace our path. But the law which produces the subtractions, appears to have a very limited action. Generally the decrements take place by one or two rows of molecules. No decrements have been observed of more than six rows; but such is the variety united with this simplicity, that were we to confine ourselves to decrements by one, two, three, and four rows, and exclude intermediate and mixed decrements; yet within these limits, the rhomboid is susceptible of more than eight million varieties of crystallization. Doubtless many of these varieties do not exist in Nature; but there is reason to expect, that numerous further discoveries in this field of inquiry will be made."

F. I was indeed greatly mistaken in supposing, that the decrements on the edges and angles could produce only a very limited number of secondary forms; but you have mentioned other decrements beside these.

B. Yes; there are mixed decrements, intermediate decrements, and compound decrements, the nature of which I shall endeavour briefly to explain. *Mixed decrements* are those, in which laminæ decrease by a different number of ranges of molecules, in breadth and in height; as for instance, by two ranges in breadth and one in height. It is easy to refer this decrement to one in which there is one row of double or triple molecules taken away in one of the two directions.

F. A decrement of two ranges of molecules in breadth and one in height, would, I suppose, form a similar angle to a decrement of a range equal to two-thirds of a molecule in breadth and one-third in height.

B. Yes; you have a correct idea of this kind of decrement; but it may be proper to observe, that decrements are never made by fractions of single ranges of molecules, though in mixed decrements, we may calculate the angles by considering them as formed by such fractions.

F. What are intermediate decrements?

B. They are formed by the abstraction of ranges which are neither parallel to the edges, nor the diagonals of the primitive crystal, but intermediate or between both (see Plate II. fig. 9.); $x y$ represents the edge of an intermediate decrement; formed by abstracting two molecules $o\,y$, from the side O I, and one molecule $o\,x$, from the side O E. The line $x y$ represents the direction of the new face of the secondary crystal, which is neither parallel to the side O I, nor to the diagonal E I, but between both. This decrement may be more easily conceived, by supposing that two molecules in length are united and taken away together. If more than two molecules are taken away in breadth, and only one in height, other kinds of intermediate decrements will be formed. The cubic nucleus (Plate II. fig. 7.) represents intermediate decrements, formed on the faces *a, b, c, d*, and *a, m, l, c*, by taking away two moleculesin breadth on each side *a, b, a, l*, and one in height, which may be regarded as one molecule, formed of two cubes. The result will be, that the cube will have a decrement of two molecules, *a, f, e, i*, on the edge *a b*, and of only one molecule on the edge *a e*. There will also be a decrement of two molecules on the edge *l a*. The edges of the new faces *a f, g h*, it will be seen, are not parallel to the diagonal of the cube *c b*. Intermediate decrements occur but in a very few cases, and they produce forms as simple as those which result from the more common laws of decrement.

F. In what respect do compound decrements differ from intermediate decrements?

B. Decrements are said to be compound when two or more laws of decrement act on different parts of the primitive crystal. The forms so produced, are called compound, or composed secondary forms; and the same name is given to crystals, in which the faces remain parallel with those of the primitive crystal; the crystal being thus formed, partly of primitive and partly of secondary faces.

F. In all the instances of decrements that you have stated, the molecules are supposed to be either rhombs, cubes, or other parallelopipeds; but as there are integrant molecules that are tetrahedral, and others that are three-sided prisms, as Plate II. figs. 10, 11. the laws of decrement with respect to these, are, I suppose, very different from those which relate to parallelopipeds.

B. It would appear so at first; but in the structure of crystals, the tetrahedral and prismatic molecules are so arranged, that taking them in groups of two, four, six, or eight, they compose parallelopipeds, and the ranges subtracted are formed of these parallelopipeds; these groups are called by Haüy *subtractive molecules.*

F. I do not immediately perceive how groups of these molecules are arranged to compose parallelopipeds.

B. I have stated, that the primitive crystal of calcareous spar or crystallized carbonate of lime is a rhomb, and have shown, that various secondary forms are the result of decrements of one or more ranges of rhombic molecules, on the edges or angles of this rhomb. If the molecules were not rhombs, but three-sided prisms, two of these prisms united at the sides *d b*, (see Plate II.

fig. 19.) would form a rhomb, and this rhomb, so composed of the two molecules, is called by Haüy the subtractive molecule. When the regular six-sided prism is the form of the primitive crystal, the integrant molecules are triangular prisms, (see Plate II. fig. 6.) where the base of the primitive crystal is seen divided by sections of laminæ, parallel to each of the sides; these sections, if carried ever so far, will form equilateral triangles, which may be conceived to be the bases of so many integrant molecules; but if these molecules unite in groups al primiv of two and two, they form rhomboids, as will be immediately perceived by inspecting the figure. Now if we conceive a series of plates piled upon the hexagon, Plate II. fig. 6. *a*, *b*, *c*, *d*, *e*, which undergo a decrement of one range of three se rhomboids on all the edges, the result of the decrement will be, a six-sided pyramid, placed on the six-sided prism. The formation of this pyramid in theory, is precisely the same as if the molecules were rhomboids, and Haüy observes, that as far as the theory is concerned, we may conceive all crystals to be formed of a congeries of parallelopipeds.

F. If crystals be really formed, as the theory of Haüy supposes, by the successive addition of decreasing laminæ, applied to the faces of the primitive nucleus; then among crystals of the same mineral, we may expect to find the smaller ones incomplete, and of a different form to the larger, owing to the decrements not having reached their termination. Will you inform me whether this be really the case?

B. Some crystals have forms that appear to be the result of a decrement which had not reached its limit, as they have faces parallel to those of the primitive crystal remaining uncovered; but in general, among a group of crystals of the same species, the smaller ones are as perfectly formed as the larger, and we never meet with that infinite variety of forms in one group, which would result from the laws of decrement being arrested, when the secondary crystals were more or less completed.

F. If this be the case, the foundation of Haüy's system seems like the baseless fabric of a vision, and however ingenious or amusing the theory may be, it ought not to find a place among systems of philosophy, unless we admit science to have her fairy land, where sylphs and gnomes may raise ideal edifices of exquisite beauty and symmetry, deficient in nothing but reality.

B. Your objections deserve attention, but I beg you to suspend your sentence on Haüy's theory, until our next conversation, when we will endeavour to ascertain, how far your objections are valid.

CHAP. VII.

Objections to Haüy's Theory of the Structure of Crystals considered. — Mode of designating Crystals by Symbols. — Nomenclature of Crystals.

B. We have now to consider the objections against Haüy's theory which you stated in our last conversation. — Have you since reflected further on the subject; or have you any other objections to bring forward?

F. I can easily understand how crystals that occur in their primitive forms, may vary in size, admitting Haüy's theory to be true; but I cannot well conceive this to be the case with secondary crystals of the same species that are found together, for the small crystals ought to be incomplete, whereas you say that they are of the same form and as perfect as the larger ones.

B. Let me beg you to inform me what makes it more difficult for you to conceive the secondary forms to vary in size than the primitive?

F. As the primary crystals increase by laminæ applied to all their sides equally, the process may cease at any time without changing the form; but if the process of crystallization ceased whilst a secondary crystal was forming by the application of decreasing laminæ, its form would vary according to the time when the process was arrested, and the crystal would be more or less incomplete.

B. This objection has not escaped the sagacity of Haüy; his answer to it does not appear perfectly satisfactory, owing, perhaps, to the concise manner in which he has treated a question that seems to involve the truth of the theory itself. I shall give his answer at length; but it may be useful first to observe, that the increase of crystals by laminæ he admits to be entirely theoretical, and only a convenient explanation of the formation of secondary crystals.

F. This admission appears to be giving up his theory altogether.

B. You are mistaken; for in whatever way crystals have been formed, it is an undoubted fact that they are composed of laminæ which may for the most part be separated from each other in the manner this theory supposes; and it does not affect the principle of the theory; whether the molecules form laminæ before they attach themselves to the crystal, or whether they attach themselves separately, but in such directions as will form laminæ on the different faces.

F. I do not at first perceive how these two modes of formation can produce the same effect.

B. If you had nine hundred soldiers to form into a compact square, with the men at equal distances from each other, you may suppose this to be effected either by arranging them first into thirty ranks of as many men in each; or if the men were sufficiently drilled, you may conceive one man to be placed in the centre, and the other men to fall into their proper places and complete the square. In either case, if the movements had been perfect, the result would be the same, and you might draw off single ranks from the front, the sides, or the rear.

F. I perceive then that Haüy's theory may be said to unfold the actual structure of crystals, and not their mode of formation.

B. This is precisely the case; but it should be observed in favour of this theory, that all calculations founded upon it give results conformable to observed facts; the angles obtained by calculation are verified by the actual admeasurement of crystals. We are further enabled to ascertain what forms certain minerals can assume, and are hereby greatly assisted in the discrimination of crystallized minerals. But I shall now state what Haüy himself has said on this subject: —

" In the exposition of the Theory of Crystallography, it has been supposed that the laminæ of which the crystals of the same species are composed, proceed from a common nucleus, undergoing decrements subjected to certain laws, upon which the forms of these crystals depend. But this is only an hypothesis adopted in order to make us more easily perceive the mutual relations of the form in question. Properly speaking, a crystal is only a regular group of similar molecules. It does not commence by a nucleus of a size proportioned to the volume which it ought to acquire, or, what comes to the same thing, by a nucleus equal to that which we extract by the aid of mechanical division; and the laminæ which cover this nucleus, are not applied successively upon each other in the same order in which the theory regards them.

"The proof of this is, that among crystals of different sizes, which are frequently attached to the same basis, the most minute are as perfectly formed as the largest; from which it follows, that they have the same structure, that is to say, they already contain a small nucleus, proportioned to their diameter, and enveloped by a number of decreasing laminæ, necessary in order that the polyhedron should be provided with all its faces. We do not perceive these various transitions from the primitive to the secondary forms, which, however, ought to be discoverable, if, during the process of crystallization, the pyramids resting on the nucleus, were formed progressively in layers from the base to the apex. This, however, is only true in general; for it sometimes happens in artificial crystallization (and it is probable that it also occurs in natural bodies), that a form, which had attained to a certain size, suddenly experiences variations by the effect of some particular circumstance. We must therefore conceive, for example, that at its very commencement a crystal, similar to the rhomboidal dodecahedron, is already a small dodecahedron, which contains a cubical nucleus, proportionably small, and that this kind of embryo continues to increase, without changing its form, by the addition of new laminæ on all sides, so that the nucleus increases on its part, always preserving the same relation with the entire crystal.

"We shall make this idea more distinct by a diagram, which refers to the dodecahedron already mentioned, and represented, by means of a plane figure. What we shall say of this figure, may be easily applied to a solid, since we may always conceive a plane figure, to be a section of a solid.

"Let *t s z s'*, (Plate II. fig. 20. A,) be an assortment of small squares, in which the square B N D G, composed of 49 squares, represents the section of the nucleus, and the extreme squares *t*, *p*, *i*, B, *f*, *c*, *s*, &c. that of the kind of steps formed by the laminæ of superposition. We may conceive, that the assortment has commenced by the square B N D G, and that different piles of small squares are afterwards applied on each of the sides of the central square; for example on the side B N, at first the five squares comprehended between *f* and *h*, afterwards the three squares contained between *c* and *e*, and then the square *e*. This progress corresponds with what would take place if the dodecahedron commenced with a cube proportioned to its volume, and which afterwards increased by an addition of laminæ continually decreasing.

"But, on the other hand, we may imagine that the assortment had been at first similar to that which is represented by Plate II. fig. 20. C. in which the square B N D G is only composed of nine molecules, and had on each of its sides only a single square *s*, *t*, *s′*, *z*. If we refer, in imagination, this assortment to the solid of which A is the section, we shall perceive that this solid had for its nucleus a cube composed of 27 molecules, each face of which was composed of nine squares, and had one additional molecule placed on the middle square, so that the decrement of one range is already exhibited in this initial dodecahedron. By the application of new squares, this assortment will become that of Plate II. fig. 20. B. in which the central square

B N D G is formed of 25 small squares, and supports on each of its sides a pile of three squares, besides a terminal square *s*, *t*, *s′*, and *z*. Here we have already two laminæ of superposition, instead of one only. Finally, by an ulterior application, the assortment of Plate II. fig. 20. B. will be changed into that of Plate II. fig. 20. A. where we see three laminæ of superposition.

“ These different transitions, of which we are at liberty to continue the series as far as we please, will give an idea of the manner in which secondary crystals may increase in magnitude, and still preserve their form ; from which we may judge that the structure keeps pace with this augmentation of volume ; so that the law, according to which all the laminæ are applied on the nucleus, when it has attained its greatest diameter, and which successively decrease, was already sketched in the nascent crystal.” There remains still much to be done to complete the theory of crystallization ; “ we have only,” says Haüy, “ traced the laws which relate to the structure of crystals, those relating to their formation require yet to be unveiled.” — *Traité de Minéralogie,* tom. i. p. 102.

F. The answer of Haüy appears satisfactory, so far as relates to the structure of crystals ; but it professes to leave untouched the question, what can determine molecules of the same kind to arrange themselves in such a variety of forms in the nascent crystal?

B. I have before stated that in saline crystallizations the presence of different ingredients in a solution will affect the crystalline form, probably the attraction of those foreign particles may change the direction of the molecules of the crystal in its first formation. There is one view of the subject which I would suggest, merely as an hypothesis, leaving to your future judgment to determine what consideration it may deserve.

F. Any hypothesis that may serve to illustrate so curious a subject I shall be glad to be acquainted with.

B. I am inclined to believe that a crystal should be regarded not merely as an assemblage of molecules, but as an individual, like a plant or an animal, possessing properties as a whole, which do not belong to the molecules separately. Thus I conceive it has the property existing in it as a whole, of attracting molecules of the same kind, and arranging them regularly over its surface, so as to increase its bulk without changing its form; and this process, I think, might properly be called *crystalline assimilation.* It is in some degree analogous to vegetable life, whilst the structure of the crystal itself may be regarded as a mineral organization.

F. Can you give me any further illustration of what you call *crystalline assimilation?*

B. Unless we admit such a property, it will be difficult to conceive, how distinct large crystals can be formed in a saline solution. Let us suppose any pyramidal crystal with acute summits to be regularly increasing in such a solution. If we place a model in wood of the same form in the solution, one or more small crystals will soon attach themselves to the acute summits of the model, it being a well-known phenomenon in saline crystallizations, that crystals most rapidly form round any projecting points. Now had not the crystals the property of distributing and arranging the molecules in certain directions, equally over their surfaces, groups of fresh crystals would always form upon their summits and angles, and we should never obtain detached crystals of any considerable bulk. But I will not detain you longer, on what I propose merely as an hypothesis.

F. You mentioned, that the angles of crystals which are ascertained by actual admeasurement, are the same as what calculations founded on Haüy's theory would give. How are the angles of crystals to be measured?

B. The instrument employed by Haüy for measuring angles, (hence called a *Goniometer*,) is similar in principle to a pair of proportional compasses, (see Plate II. fig. 21.) If the inner edges of the arms *g*, *k*, be applied to the two contiguous faces of a crystal, perpendicular to the edge where the faces meet, the inner edges will measure the angle; a similar angle will be formed by the larger arms *i d*; and these being applied to a protractor, or the angle being drawn and measured, will give the angle of inclination under which the two faces or planes of the crystal meet. Great care is required in the use of this instrument; in order that the planes of the crystal to be measured may exactly fill the inner edges *g k*, of the goniometer. For this purpose, the Count de Bournon recommends, that the crystal should be held on an horizontal level with the eye and light, when standing in an erect position, in order that we may discern, whether there is any interstice left between the face of the crystal and the edges of the instrument; and to prevent any error from this source, he recommends, that a lens with a considerable magnifying power, be placed on a stand level with the eye, that we may see, whether the crystal completely fills the angle formed by the edges *g k*, and that we may, at the same time, have both the hands at liberty, to adjust the instrument accurately. With these precautious measurements may be taken correctly within half a degree, when the crystals are of moderate size, and have level surfaces.

F. When the crystals are very small, it must be extremely difficult to measure the angles accurately with such an instrument.

B. Yes; in the measurement of minute crystals, it can scarcely be depended on within two degrees. It is difficult to conceive how M. Haüy with this goniometer could give the angles of crystals so correctly as he has done. By the aid of calculation, he was indeed enabled to verify the truth of his admeasurements, and detect any considerable errors into which he might have fallen from the defect of his instrument; still his address and sagacity in the use of it are truly surprising. An instrument of a far more perfect kind has been invented by Dr. Wollaston, which may be called a *reflecting goniometer*, as it measures the angles, formed by the rays of light reflected from two faces of a crystal, the crystal being attached to the axis of a graduated circle. With this instrument, the angles of small crystals may be measured correctly, within a few minutes. The old goniometer is, however, the most portable and convenient for the traveller. Before I dismiss the subject of crystallography, it may be proper to state, that in order to denote the various decrements by which secondary crystals are supposed to have been formed, Haüy has invented certain symbols *, which are so concise, simple, and ingenious, that I shall abridge his description of them for your use.

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* Traité de Minéralogie, tom. i. p. 110.

Symbols employed to designate the Laws of Decrement by which secondary Crystals are formed.

In designating crystals, the vowels represent the solid angles; they are placed at the four angles of the superior base as A, E, I, O, of the oblique parallelopiped, (Plate II. fig. 22.) The letters begin at the top, and go from right to left. The consonants B, C, D, F, G, H, denote the edges, and are placed on the middle of the edges of the superior base, and upon the two longitudinal edges which occur first in going from left to right. These consonants are likewise arranged in the alphabetical order, and according to the usual mode of writing.

The letters P, M, T, which are the initials of the syllables of which the word *primitive* is composed, are placed, the first on P on the middle of the superior base, and M and T on the two lateral faces exhibited to view.

Each of the four solid angles, or of the six edges marked by letters, is susceptible in the present case, on account of the irregular form of the parallelopiped, of undergoing particular laws of decrement. Hence the reason why they are marked each with a different letter. But as the laws of decrement act with the greatest symmetry possible, every thing which takes place with respect to the angles and edges marked with letters, takes place also with respect to the opposite analogous angles and edges which are not marked, or are not visible. It was only necessary to mark the number of solid angles or edges which undergo distinct decrements, because these decrements include likewise implicitly all those which take place upon analogous angles or edges.

In some cases, however, it is necessary to indicate these last angles or edges. In such cases, the small letters, having the same names as the capitals, are employed for the purpose. The angles analogous to A, E, I, O, are denoted by *a*, *e*, *i*, *o*; and the edges analogous to B, C, D, F, G, H, are denoted by *b*, *c*, *d*, *f*, *g*, *h*.

To indicate the effects of decrements by one, two, three, four, or more ranges in breadth, the figures 1, 2, 3, 4, &c. are employed (as will be immediately explained); and, to indicate the effects of decrements by 2, 3, &c. ranges in height, the fractions $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. are employed.

The three letters P, M, T, serve to distinguish either the form of the nucleus, without any modification, when they alone constitute the symbol of the crystal, or the faces parallel to those of the nucleus, in the case where the decrements do not reach their limit; and then these letters are combined in the symbol of the crystal with those which relate to the angles or edges that have undergone decrements.

Let us suppose, that one of the solid angles, such as O, is intercepted by a single additional face. The decrement which produces this face, may take place either on the base P, or on the face T, which is on the right of the observer; or on the face M, which is on the left. In the first case, the figure marking the decrement is placed above the letter O; in the second case, the figure is placed like an ordinary exponent; in the third case, it is placed on the left side, and somewhat above the letter.

Thus, $\overset{2}{O}$ denotes the effect of a decrement on the angle O, by two ranges in breadth, parallel to the diagonal of the base P, which passes through the angles E and I. O^3 indicates the effect of a decrement on the angle O, by three ranges in breadth, parallel to the diagonal of the face T, which passes through the angles I and *p*. ${}^4O$ indicates the effect of a decrement by four ranges in breadth, parallel to the diagonal of the face M that passes through the angles E and *p*.

When the decrement relates to some one of the three other solid angles, I, A, E, the observer is conceived to move round the crystal till he is opposite to that angle, as he is supposed to be opposite to the angle O in the case which we have been describing; or, what comes to the same thing, he is conceived to turn round the crystal till the solid angle that he is considering be exactly opposite to him, and it is relative to that position that a decrement is said to take place towards the right or towards the left.

For example, if we are speaking of the solid angle A, the sign A^2 will represent the effect of a decrement by two ranges on the surface A E *s r*; (Plate II. fig. 22.), or upon that which is opposite to T in the same figure; and ^3A will represent the effect of a decrement by three ranges upon the face A I *u r*, or upon that which is opposite to M, (fig. 22.) the angle A being supposed to be turned round to O.

As to the decrements on the edges, those which take place towards the boundary B C F D of the base, are expressed by a number placed above or below the letter, according as their effect takes place in going up or going down, supposing them to set out from the edge to which they are referred; while those which take place on the longitudinal edges G, H, Plate II. fig. 22, are indicated by an exponent placed on the right or the left of the letter, according as they take place in one direction or the other. Thus $\overset{2}{D}$ expresses a decrement by two ranges proceeding from D towards C; $\overset{3}{C}$, a decrement by three ranges going from C towards D; $\underset{2}{D}$, a decrement by two ranges, descending upon the face M; ${}^{3}H$, a decrement by three ranges, proceeding from H towards G; ${}^{4}G$, a decrement by four ranges, proceeding from G towards the edge opposite to H, &c.

When it is necessary to denote by a small letter, such as *d*, a decrement upon the edge *u r*, (Plate II. fig. 22.), opposite to the edge denoted by the capital letter D, we must suppose the crystal turned upside down. Hence $\overset{2}{d}$ will express a decrement by two ranges upon the base *p*, just as $\overset{2}{D}$ expresses a similar decrement on the base P. For the same reason, $\underset{3}{c}$ will express a decrement by three ranges proceeding from *s p* towards E O, fig. 22.

If the same solid angle, or the same edge, undergo several successive decrements on the same side, or different decrements which take place on different sides, in that case, the letter pointing out the angle or edge is repeated as often as the decrements, varying the figure each time, to make it correspond with the particular decrements pointed out. Thus, $\overset{2}{D}\,\underset{3}{D}$ will denote two decrements upon the edge D, one of two ranges upon the base P, another of three ranges upon the face M. ${}^{2}H\;{}^{4}H$ will denote two decrements, the one by two ranges, the other by four, on the left of the edge H.

Mixed decrements are marked according to the same principles, employing the fractions $\frac{2}{3}$, $\frac{3}{4}$, &c. which represent them; the numerator referring to the decrements in breadth, and the denominator to decrements in height.

The method of describing the intermediate decrements still remains to be explained. This will be best done by an example. Let A E O I, Plate II. fig. 9. be the same face as in fig. 22. Let us suppose, a decrement by one range of double molecules, according to lines parallel to xy, so that Oy measures the double length of a molecule, Ox is equal to a single molecule. This kind of decrement is written in this manner, $(\overset{1}{O}\,D^{1}\,F^{2})$. The parenthesis lets us know, in the first place, that the decrement is intermediate; $\overset{1}{O}$ indicates that it takes place by one range upon the angle marked by that letter; and that it belongs to the base A E O I, (Plate II. fig. 22.); $D^{1}\,F^{2}$ indicates that there is one length of a molecule taken away along the edge D, and two lengths along the edge F.

It is useful to have a language to denote these symbols, so that they may be *easily written* down when dictated by another person. On that account, we shall mention here the mode followed for that purpose. The symbols O^2, ^3O, are thus read: O *two on the right*, O *three on the left*, $\overset{2}{O}$ $\underset{4}{O}$ thus, O *under two*, O *above four*. Finally, the symbol $(\overset{1}{O}\ D^1\ F^2)$ thus, *in a parenthesis*, O *under one*, D *one*, F *two*.

The order in which these letters must be placed, to denote a secondary crystal, is as follows: we begin with the prism or the middle part, and indicate its different faces as they present themselves successively to the eye; then pass to the faces of the summit or the pyramid.

Suppose, now, that Plate III. fig. 2. represents the *bibinary* variety of felspar, the primitive form of which is seen in Plate III. fig. 34. In this variety, the face *l* (Plate III. fig. 2.) results from a decrement by two ranges on the edge G, (fig. 34.) going towards H. The face M corresponds with that which is marked with the same letter in the primitive crystal, and which is partly concealed by the effect of the decrement. The face T, (fig. 2.) is parallel to T, (fig. 34.) The pentagon *x*, (fig. 2.) comes from a decrement of two ranges on the angle I, parallel to the diagonal A O. As this decrement does not reach its limit, the summit exhibits a second pentagon P, (fig. 2.) parallel to the base P, (fig. 34.) All this description may be exhibited in symbolic language, as follows: $G^2\ M\ T\ \overset{2}{I}\ P$.

In order to prevent beginners from finding any thing ambiguous in this symbolical mode of writing, especially in complicated cases, Haüy is in the habit of placing under the different letters which compose the symbol, those which correspond to them in the figure. If we adopt this mode, which is a considerable improvement, the symbol denoting *bibinary* felspar, will be as follows: $G\ {}^{2}M\ T\ \overset{2}{I}\ P.$

$$\begin{array}{ccccc} G & {}^{2}M & T & \overset{2}{I} & P. \\ l & M & T & x & P. \end{array}$$

These letters thus written below, enable us to compare the symbol with the figure, and thus to decypher the meaning with facility, how complicated soever it should be. But some more observations will be necessary, in order to understand fully the way in which these symbols are employed.

Let us now, then, turn our attention to parallelopipeds of a more regular form.

In the cube represented in Plate II. fig. 12. only the superior base is marked with letters, because what takes place with respect to it may be applied indifferently to any of the other faces.

The same mode is followed in writing the symbols for these different forms, only the letters that have the same name and the same figures are not repeated. An example will render the method evident. Plate IV. fig. 17. represents the most common variety of the cymophane, the nucleus of which is a rectangular parallelopiped (Plate IV. fig. 33.) The symbol of the secondary crystal will be

$$\begin{array}{llllll} M & T & {}^{2}G & G^{2} & \overset{1}{B} & A^{\frac{2}{3}}\;{}^{\frac{2}{3}}A. \\ M & T & s & & i & o \end{array}$$

This variety is called *annular cymophane.*

The symbol will be better understood if we state, that the nucleus, Plate IV. fig. 3. does not differ greatly from the cube; but the upper face P of the primitive crystal, and the opposite face are entirely concealed by the decrements. The secondary face s is formed by a decrement of two ranges from the edge G of the primitive crystal (Plate IV. fig. 33.), to the left of the face M and s' by two on the edge G to the right from the latter edge. The face i is produced by a decrement of one range in height on the face P, proceeding from the edge B, and the face o is produced by a decrement of two ranges in breadth, and three in height on the angle A.

We must take care not to confound ${}^{2}G\,G^{2}$ with $G^{2}\,{}^{2}G$. The first symbol indicates the decrements which take place on the face T, (Plate IV. fig. 33.) and on the face opposite to it, going from the edges G towards those that correspond with them behind the parallelopiped. The second indicates the decrements which take place upon the face M, and which meet each other in the middle of that face. If these two decrements took place simultaneously, their symbol would be ${}^2G^2$.

In the preceding symbols, each letter, such as ${}^2G$ or G^2 can only be applied to a single edge, situated to the right or the left, as the letter G is in the fig. But ${}^2G^2$ applies indifferently to the one edge or the other. Hence it is needless to repeat that letter.

The rhomboidal dodecahedron derived from the cube, (Plate II. figs. 3. and 17.) is expressed by the symbol $\overset{1}{B}B$. The octahedron derived from the cube is expressed thus, $\overset{1}{A}\,{}^1A^1$.

The rhomboid, supposing it placed in the most natural aspect, (that is to say, so that the two solid angles composed of three equal plane angles, are in the same vertical line,) has, properly speaking, no base, but merely summits, which are the extremities of its axis. If all the lateral angles were indicated by letters, the three nearest the superior summit, would have the letter E, and the three nearest the inferior summit the letter *e*. Plate II. fig. 13.

As the rhomboid has its six faces equal and similar, it is only necessary to consider the decrements relative to one of these faces; because all the others are mere repetitions of this. These observations suggest the following rules: 1. The decrements which set out from the superior angle A, or the superior edge B, will have the figure indicating the number of ranges placed below A and B. 2. Those which set out from the lateral angles E will have their figures situated at the side and towards the top of the same letter. 3. With respect to those which set out from the inferior angle *e*, or from the inferior edge D, the figure will be placed above the letter *e* or D.

If we want to denote the result of a decrement by one range upon all the angles of the regular octahedron (Plate IV. fig. 14.), we have only to write $\overset{1}{A}\,{}^{1}A^{1}$. To indicate the result of a decrement by one range on all the edges, we write $\overset{1}{B}\,\underset{1}{B}$. The first of these decrements produces a cube, the second a rhomboidal dodecahedron.

In some species, as in the nitrate of potash, the primitive octahedron, the surface of which is composed of eight isosceles triangles, similar 4 and 4 to each other, ought to have the position represented in Plate III. fig. 1., that the secondary crystals may have the most natural attitude; that is to say, that the edges which join the two pyramids which compose the octahedron, ought to be two of them in a vertical direction, as F, and two in a horizontal, as B.

The figure denoting the number of ranges, will be placed under the letter, to denote decrements proceeding from B. It will be placed at one side, or below, to denote those proceeding from A; according as their effect respects the triangle A I A, or the triangle A I F. It will be placed above, or below, for those which proceed from C, according as their effect is produced on the first or the second of these triangles. It will be placed at one side for the decrements which proceed from F. Finally, it will be placed above, below, or on either side, for the decrements that proceed from I, according as their effect takes place towards B or towards F.

The tetrahedron being always regular, when it becomes the primitive form, it will be expressed as in Plate II. fig. 15. To indicate, for example, a decrement by three ranges on all the edges, we should write $\underset{3}{B}\overset{3}{B}$; and to indicate a decrement by two ranges upon all the angles, we should write $\underset{2}{A}{}^{2}A^{2}$, as in the case of the regular octahedron.

A simple inspection of Plate II. fig. 16. is sufficient to make us understand the symbols in the case of regular six-sided prisms.

In the rhomboidal dodecahedron (Plate II. fig. 17.), each solid angle composed of three planes may be assimilated to a summit of the obtuse rhomboid. Hence, it is only necessary to give letters to one face.

To enable any person merely to read these symbols, and to understand them, the following rules will be sufficient, and will serve as a kind of epitome of the preceding observations:

1. Every vowel employed in the symbol of a crystal indicates a solid angle, marked with the same letter in the figure which represents the nucleus. Every consonant indicates the edge which has the same letter in the figure.

2. Each vowel and consonant is accompanied by a figure, the value and position of which indicate the law of decrement which the corresponding angle or edge undergoes. We must except the three consonants P, M, T; each of which, when it appears in the symbol of a crystal, indicates that the crystal has faces parallel to those faces which have the same letters on the figure of the nucleus.

3. Each letter contained in the symbol of a crystal is understood, with the figure belonging to it, to apply to all the angles or edges which have the same function as it has in the figure, and is marked with the same letter.

4. Every number joined to a letter indicates a decrement, setting out from the angle or the edge denoted by that letter. If the number is a whole number, it indicates how many ranges in breadth are subtracted, supposing each plate to have only the thickness of one molecule. If the number is a fraction, the numerator indicates the number of ranges subtracted in breadth, and the denominator the number of ranges subtracted in height.

5. According as the number is placed below or above the letter which it accompanies, it indi-

cates that the decrement descends or ascends, setting out from the angle or edge marked by the letter. If it is placed towards the top, and either on the right or the left side of the letter, it indicates a decrement in a lateral direction, either to the right or to the left of the angle or edge marked by the letter.

6. When a letter is twice repeated, with the same number placed on two different sides, as ${}^{2}G\ G^{2}$ or $G^{2}\ {}^{2}G$, ${}^{2}A\ A^{2}$ or $A^{2}\ {}^{2}A$, the two edges, or the two angles which it marks, ought to be considered on the figure in the same relative positions; that is to say, for example, that in the symbol ${}^{2}G\ G^{2}$, the quantity ${}^{2}G$ indicates the effect of decrement on the edge G situated at the left, and the quantity G^{2} the effect of decrement upon the edge situated at the right.

7. When a letter has the same number both on the left and the right side, as ${}^{3}G^{3}$, it applies equally to all the edges G. The same thing holds with the letters which belong to the angles.

8. The parenthesis, as for example $(\overset{3}{O}\,D^{1}\,F^{2})$, indicates an intermediate decrement. The letter $\overset{3}{O}$ indicates, in the first place, that the decrement takes place by three ranges on the angle O, and that its effect is ascending. $D^{1}\,F^{2}$ indicate, that for one molecule subtracted along the edge D, there are two molecules subtracted along the edge F.

9. Every small letter occurring in the symbol of a crystal, indicates the angle or the edge diametrically opposite to that which has the capital letter of the same name in the figure, where the small letter is omitted as superfluous. We must except the letter *e*, which is always employed in the rhomboid, and which indicates, according to the principle, the angle opposite to that which bears the letter E.

10. When a symbol contains two letters of the same name, the one large, the other small, with different numbers attached to them, the two opposite edges or angles to which these letters belong, are conceived to undergo each exclusively, the law of decrement indicated by the number attached to the letter.

11. Every letter, whether large or small, marked by a number having a zero following it, as A *o*, D *o*, indicates that the decrement denoted by that number, does not take place on the particular edge or angle denoted by the letter.

Nomenclature of Crystals.

To abridge the labour of describing the various forms of crystals, Haüy has invented a new nomenclature *, in which he has endeavoured to designate each principal variety of form, by a name that shall indicate at once the form itself,

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* Traité de Minéralogie, tom. i. p. 186.

or the peculiar structure or decrement on which the form depends. — The introduction of new terms into any science, without manifest necessity, is always to be regretted, and it may be fairly doubted whether some of those introduced in the nomenclature of Haüy, are not more likely to burden the memory of the student than facilitate his progress. Several of the terms, however, are very expressive, and sufficiently simple to be easily understood; and as they frequently occur in the descriptions of foreign mineralogists, and are also employed to designate the crystallized minerals in the splendid collection at the British Museum, open to public inspection, it is necessary that the learner should be acquainted with them, or at least have a vocabulary to which he may refer for an explanation, when wanted. The insertion of the nomenclature was therefore deemed proper in an introductory work.

Primitif or *Primitive*, added to the name of the species, always denotes the primitive form of the crystals of that species. Thus zircon primitif.

The secondary forms of crystals may be considered under six different points of view.

I. *Secondary forms, considered in relation to the modifications produced in the primitive form,* *by a combination of the faces of the latter with those which result from the laws of decrement.*

Thus a crystal may be called

Pyramidé, pyramidated, when the primitive form is a prism, and, in the secondary form, is terminated at each extremity by a pyramid, having as many faces, as the prism has sides.

Prismé, when the primitive form is composed of two pyramids united base to base; and, in the secondary form, these pyramids are separated, and a prism is interposed. Thus zircon prismé (Plate III. fig. 30.)

Semi-prismé, as in the preceding, except that the interposed prism has only half as many sides as there are edges at the common base of the two pyramids.

Basé, when the primitive form is a rhomb, or is composed of two pyramids united base to base; and, in the secondary form, the summits of the rhomb or double pyramid are truncated by faces perpendicular to the axis of the crystal.

Epointé, when all the solid angles of the primitive form are truncated, each by one face. Thus strontiane sulfatée (sulphate of strontian) epointée (Plate III. fig. 28.)

Bisépointé, *triépointé*, *quadriépointé*, when each solid angle of the primitive form is replaced by two, or three, or four faces. Thus analcime triépointé (Plate IV. fig. 3.)

Emarginé, when all the edges of the primitive form are truncated, each by one face.

Bisémarginé, *triémarginé*, when each edge of the primitive form is replaced by two, or three faces.

Périhexaèdre, when the primitive form is a prism of four sides, and, in the secondary form, is converted into a prism of six sides by the decrements; or, in other words, is truncated on two of its lateral edges.

Périoctaèdre, *péridécaèdre*, *péridodécaèdre*, when, as in the preceding, a four-sided prism is converted into a prism of eight, or ten, or twelve sides. The term péridodécaèdre is also employed, when the primitive form is a regular six-sided prism, and, in the secondary form, has each of its lateral edges truncated by one face.

Raccourci (shortened) when the primitive form is a prism, whose bases are rhombs, and, in the secondary form, each of the two lateral edges, contiguous to the *longer* diagonals of the bases, is truncated by one face; in consequence of which the crystal appears diminished in length.

Rétréci (narrowed), when the primitive form is the same as in the preceding, but, in the secondary form, each of the two lateral edges, contiguous to the *shorter* diagonals of the bases, is truncated; in consequence of which the crystal appears diminished in breadth. Thus baryte sulfatée (sulphate of barytes) rétrécie (Plate III. fig. 24.)

II. *Secondary forms, considered merely as geometrical forms.*

A crystal may be called

Cubique, when it exhibits a cube, as a secondary form.

Cuboïde, when the form differs very little from a cube. Thus chaux carbonatée (carbonate of lime) cuboïde (Plate III. fig. 16.)

Tétraèdre, when the crystal presents a regular tetraedron, as a secondary form.

Octaèdre, when it presents an octaedron, as a secondary form.

Prismatique, when the form is a right or oblique prism, whose sides are inclined to each other at an angle of 120°.

Docédaèdre, when the surface of the crystal presents twelve triangular, quadrangular, or pentagonal faces, all equal and similar, or whose plane angles possess only two different measures. Thus zircon dodécaèdre (Plate III. fig. 31.); also cuivre gris (grey copper) dodécaèdre (Plate V. fig. 23.)

Icosaèdre, when the crystal is bounded by twenty triangles, of which twelve are isosceles, and eight equilateral; thus fer sulphuré (sulphuret of iron) icosaèdre (Plate V. fig. 8.)

Trapézoïdal, when the surface is composed of twenty-four trapeziums, all equal and similar. Thus grenat (garnet) trapézoïdal (Plate IV. fig. 10.)

Triacontaèdre, when the crystal is bounded by thirty rhombs. Thus fer sulphuré (sulphuret of iron) triacontaèdre (Plate V. fig. 9.)

Ennéacontaèdre, when the surface presents ninety faces.

Birhomboïdal, when the surface is composed of twelve rhombic faces, which, being taken six and six and prolonged in idea, till they intercept each other, would form two different rhombs.

Trirhomboïdal, when, as in the preceding, three different rhombs would be formed. Thus chabasie trirhomboïdale (Plate IV. fig. 4.)

Biforme, when the crystal comprises a combination of two remarkable forms, as the cube, rhomb, octaedron, dodecaedron with rhombic faces, &c.

Triforme, when, as in the preceding, three forms are concerned. Thus cobalt arsenical triforme (Plate V. fig. 1.)

Cubo-octaèdre, when the crystal presents a combination of the two forms, indicated by the name, *viz.* a cube and octaedron.

Cubo-dodécaèdre, *cubo-tétraèdre*, when, as in the preceding, the forms are a cube and dodecaedron, or a cube and tetraedron. Thus fer sulfuré (sulphuret of iron) cubo-dodécaèdre (Plate V. fig. 7.)

Trapézien, when the lateral planes are composed of trapeziums, situated in two ranges between the two bases. Thus baryte sulfatée (sulphate of barytes) trapézienne (Plate III. fig. 25.)

Di-tétraèdre, when the form is a tetraedral prism with diedral summits. Thus fer arsenical (arsenical iron) ditétraèdre (Plate V. fig. 5.)

Di-hexaèdre, dioctaèdre, when the form is a hexaedral prism with triedral summits, or an octaedral prism with tetraedral summits. Thus topaze dioctaèdre (Plate III. fig. 39.)

Di-décaèdre, didodécaèdre, when the crystal is a decaedral prism with pentaedral summits; or a dodecaedral prism with hexaedral summits.

Tri-hexaèdre, when the surface exhibits three ranges of faces, placed one above the other, each range containing six faces.

Tétra-hexaèdre, penta-hexaèdre, epta-hexaèdre, tri-octaèdre, tri-dodécaèdre, when, as in the preceding, the crystal presents certain ranges of a given number of faces, as indicated by the several names respectively.

Bi-géminé, when the crystal exhibits a combination of four forms, which, taken two and two, are of the same kind.

Amphi-hexaèdre, when the faces of the crystal, counted in two different directions, give two hexaedral outlines, or are found to be six in number.

Sex-décimal, when a prism, or the middle part of a crystal, has six faces, and the two summits, taken together, ten faces; or the reverse. Thus feldspath sexdécimal (Plate III. fig. 37.)

Quadri-décimal, octo-décimal, sex-duodécimal, octo-duodécimal, déce-duodécimal, octo-sexdécimal, sex-octonal, &c. when, as in the preceding, a prism, or the middle part of a crystal, and the two summits, have the number of faces indicated by the several names respectively. Thus feldspath quadri-décimal (Plate III. fig. 36.); also corindon (corundum) octo-duodécimal (Plate IV. fig. 18.); also plomb carbonaté (carbonate of lead) sex-octonal (Plate V. fig. 19.)

Péripolygone, when a prism has a great number of sides.

Surcomposé, when the form is very complex. Thus fer sulfuré (sulphuret of iron) surcomposé (Plate V. fig. 17.) [illegible] //

Anti-ennéaèdre, when there are nine faces on two opposite parts of the crystal. This form appears in a variety of the tourmaline, in which each summit has nine faces, and the prism twelve sides; whereas the prism usually has nine sides.

Prosennéaèdre, when there are nine faces on two adjacent parts of the crystal. This form also belongs to a variety of the tourmaline, in which the prism has nine sides, and one of the summits nine faces.

Récurrent, when the faces of the crystal, being counted in annular ranges from one extremity to the other, furnish two different numbers, which succeed each other several times, as 4, 8, 4, 8, 4.

Equidifférent, when a different number of faces is presented by the prism and by each summit; and these three numbers form a series in arithmetical progression, as 6, 4, 2. Thus amphibole (hornblende) equidifférent (Plate IV. fig. 24.)

Convergent, when the series of numbers, taken as in the preceding variety, is rapidly convergent, as 15, 9, 3.

Impair, when a different number of faces is presented by the prism and by each summit; but the three numbers follow no law of progression. Thus tourmaline impaire (Plate IV. fig. 13.)

*Hypéroxide** (acute to excess), which is a name given to a variety of carbonate of lime, embracing a combination of two acute rhombs, of which, however, one is much more acute than the other (Plate III. fig. 21.)

Sphéroïdal when it is bounded by several convex faces, as one variety of the diamond, which has forty-eight convex faces (Plate IV. fig. 29.)

Plano-convexe, when, as in a variety of the

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* This term is particularly objectionable, being employed in a different sense in chemistry.

diamond, some of the faces are plane, and others curved.

III. *Secondary forms, considered in regard to certain faces or edges, remarkable by their position, or relative situation.*

Thus a crystal may be called

Alterne, when on two parts, an upper and lower part, it presents faces, which alternate among themselves, but which correspond with each other, when the two parts are compared.

Bisalterne, when, as in the preceding case, the alternation takes place, not only between the face on the same part, but also between those on the two parts.

Bibisalterne, when there is on both parts two sets of bisalterne faces. Thus mercure sulfuré (sulphuret of mercury) bibisalterne (Plate V. fig. 29.)

Annulaire, when a hexaedral prism has six, or an octaedral prism eight marginal faces, disposed in a ring about each base; or when these prisms are truncated on all their terminal edges.

Monostique, when a prism of a given number of sides has on the margin of each base a range of faces of a different number from that of the sides; these faces may be all marginal, or some may be marginal, and others may replace the solid angles; or they may be viewed as truncations of the terminal edges and solid angles.

Thus topaze monostique (Plate III. fig. 40.); also epidote monostique (Plate IV. fig. 15.)

Distique, when, instead of one range, as in the preceding variety, there are two ranges of faces about each base.

Subdistique, when two of the faces, disposed in the same range about each base, are surmounted by two additional faces, which seem to constitute the beginning of a second range.

Plagièdre, when a crystal has faces situated obliquely, or in a slanting direction.

Dissimilaire, when two ranges of faces, situated one above the other towards each summit, have a want of symmetry. Thus epidote dissimilaire (Plate IV. fig. 16.)

Encadré, when a crystal has faces, which form a kind of *frame* about the faces of a more simple form, already existing in the same species.

Prominule, when a crystal has edges, which contain a very obtuse angle, and of course project but little.

Zonaire, when the crystal has about its middle part a range of faces, which form a kind of zone.

Apophane (manifest), when certain faces or certain edges present some useful indication for discovering the position of the nucleus, which it would otherwise be difficult to determine.

Emoussé (blunted), when there are faces, which intercept and apparently blunt certain edges or angles, which, without these faces would be more projecting than the other edges or angles.

Contracté, a name applied to a dodecaedral variety of the carbonate of lime, in which the bases of the terminating pentagons suffer a kind of contraction, in consequence of the inclination of the lateral faces.

Dilaté, a name applied to another variety of the dodecaedral carbonate of lime, in which the bases of the pentagons, which terminate the crystal, suffer a kind of dilatation, in consequence of the inclination of the lateral faces (Plate III. fig. 19.)

Acuteanglé, a term employed to designate a hexaedral prism of carbonate of lime, which has its solid angles truncated by very acute-angled triangles.

Defective, a name particularly applied to a variety of the borate of magnesia, in which four of the solid angles of the primitive cube are truncated, each by one face, while the opposite solid angles remain untouched.

Surabondante, a name applied to another variety of the borate of magnesia, in which each of the solid angles of the cube, which were untouched in the preceding variety, is terminated by four faces (Plate III. fig. 9.)

IV. *Secondary forms, considered in regard to the laws of decrement, on which they depend.* *

A crystal may be called

Unitaire, when its form is produced by a single decrement of one range of particles. Thus feldspath unitaire (Plate III. fig. 36.)

Bisunitaire, *triunitaire*, *quadriunitaire*, when there are two, three, or four decrements by one range of particles. Thus epidote bisunitaire; (Plate IV. fig. 14.); also pyroxene (augite) triunitaire (Plate IV. fig. 22.)

Binaire, when the secondary form depends on one decrement by two ranges of particles.

Bibinaire, *tribinaire*, when it depends on two or three decrements, each by two ranges of particles, according to the names respectively. Thus chaux carbonatée (carbonate of lime) bibinaire (Plate III. fig. 21.)

Ternaire, *biternaire*, when the secondary form is produced by one or two decrements, each by three ranges of particles, according to the names respectively.

Unibinaire, when there are two decrements, the one by one range, and the other by two ranges

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* By the *exponent* is meant the number, which indicates how many ranges of particles are subtracted in the several decrements. In mixed decrements, the exponent is a fraction, of which both terms are greater than unity; the numerator expresses the decrement in breadth, and the denominator the decrement in height.

of particles. Thus staurotide unibinaire (Plate IV. fig. 27.)

Uniternaire, when one of the two decrements is by one range of particles, and the other by three ranges. Thus titane siliceo-calcaire uniternaire (Plate IV. fig. 36.)

Binoternaire, when, of the two decrements, one is by two and the other by three ranges of particles. Thus fer oligiste (specular oxide of iron) binoternaire (Plate V. fig. 12.)

Equivalent, when the exponent or index of one decrement is equal to the sum of the exponents of the other decrements. Thus chaux sulfatée (sulphate of lime) équivalente (Plate III. fig. 12.)

Soustractif, when the exponent, which relates to one decrement, is less by unity than the sum of the exponents of the other decrements.

Additif, when the exponent of one decrement exceeds by unity the sum of the exponents of the other decrements.

Progressif, when the exponents form a series of numbers in arithmetical progression, as 1, 2, 3. Thus fer oligiste (specular oxide of iron) progressif (Plate V. fig. 14.)

Disjoint, when the decrements differ much from each other, as from 1 to 4 or 6.

Partiel, when some part of the primitive form remains without decrements, while other parts, similarly situated, undergo them. Thus cobalt gris (grey cobalt) partiel (Plate V. fig. 2.)

Soudouble, when the exponent of one decrement is half the sum of the other exponents. Thus axinite soudouble (Plate IV. fig. 7.)

Soutriple, *souquadruple*, when the exponent of one decrement is only one-third or one-fourth the sum of the other exponents.

Doublant, when one of the exponents is twice repeated in a series which would otherwise be regular.

Triplant, *quadruplant*, when one of the exponents is three or four times repeated in a series, which would otherwise be regular.

Identique, when the exponents of two simple decrements are equal to the terms of the fraction, which express a third and mixed decrement in the same crystal.

Isonome (equality of laws), when the exponents, which mark the decrements on the edges, are equal; and also those, which denote the decrements on the angles. Thus cuivre sulfatée (sulphate of copper) isonome (Plate V. fig. 27.)

Mixte, when the form results from a single mixed decrement.

Pantogène, (originating from all its parts,) when every edge and every solid angle undergoes a decrement. Thus baryte sulfatée (sulphate of barytes) pantogène (Plate III. fig. 26.)

Bifère, when each edge and each solid angle suffers two decrements.

Entouré, when there are decrements on all the edges and on all the solid angles about the base of a prismatic nucleus.

Opposite, when one decrement is made by one range of particles, and another decrement is intermediate.

Synoptique, when the laws of decrement in any given crystal offer a kind of synopsis of the laws, which operate in the formation of all the other secondary crystals of that species, or at least the greater part of them.

Retrograde, which is a name applied to a variety of the carbonate of lime, whose form depends chiefly on two mixed decrements; and the faces thence resulting seem to retrograde, that is, they appear to be thrown backward toward that side of the axis, which is most removed from that face, where the decrements commence.

Ascendant, when all the laws of decrement have an ascending direction, setting out from the angles or lower edges of a rhombic nucleus.

V. *Secondary forms, considered in regard to certain geometrical properties which they present.*

Thus a crystal may be called

Isogone (equiangular), when the faces which exist on certain parts, differently situated, form among themselves equal angles. Thus tourmaline isogone. (Plate IV. fig. 12.)

Anamorphique (inverted form), when the crystal cannot be placed in its most natural position, without apparently inverting that of the nucleus. Thus stilbite anamorphique. (Plate IV. fig. 2.)

Rhombifère, when certain faces of the crystal are true rhombs, although, from the manner in which they are connected with the contiguous faces, they do not, at first view, appear to be regular figures. Thus quartz rhombifère (Plate III. fig. 33.)

Equiaxe, when the secondary form is a rhomb, whose axis is equal to that of the primitive form, which is also a rhomb. Thus chaux carbonatée (carbonate of lime) equiaxe (Plate III. fig. 14.)

Inverse, when the secondary form is a rhomb, whose *edges* contain angles equal to the plane angles of the primitive rhomb, which is itself a rhomb, and whose *plane angles* are equal to those contained by the edges of the primitive rhomb. Thus chaux carbonatée (carbonate of lime) inverse (Plate III. fig. 15.)

Métatastique (transferred), when the secondary crystal has some of its plane angles and some of those, formed by the inclination of its faces, equal to certain angles of the nucleus, which are thus in a certain sense transferred to the secondary form. Thus chaux carbonatée (carbonate of lime) métastatique (Plate III. fig. 6. and 17.)

Contrastant, which is a name applied to a very *acute* rhomb of carbonate of lime, whose angles, when compared with those of the variety *equiaxe*, undergo an inversion, (similar to that described in the variety *inverse*,) in consequence of which, certain parts of the crystal are made to resemble a very *obtuse* rhomb, thus producing a kind of contrast in the same crystal.

Persistant, a name applied to a variety of carbonate of lime, in which certain faces are intercepted by the contiguous faces, in such manner, that they preserve the same measures of their angles, which they would have had without being thus intercepted; these angles may, however, have different relative positions.

Analogique, when the form presents many remarkable analogies. Thus chaux carbonatée (carbonate of lime) analogique (Plate III. fig. 23.)

Paradoxale, when the structure presents singular and unexpected results.

Complexe, when the structure is rendered complicate by uncommon decrements; as when some are mixed and others intermediate.

VI. *Secondary forms considered in regard to certain peculiar properties.*

Thus a crystal may be called

Transposé, when it is composed of two halves of an octaedron, or of two portions of some other form, of which one seems to have turned upon the other through a space equal to one-sixth of the circumference of a circle.

Hémi-trope, when it is composed of two halves of the same crystal, of which one half seems to be inverted in regard to the other; (see art. 82.) Thus feldspath hémitrope (Plate III. fig. 39.)*

Rectangulaire, a name applied to that variety of the staurotide, composed of two prisms, which cross at right angles.

Obliquangle, a name applied to another variety of the staurotide, in which the two prisms cross at an angle of 60° (Plate IV. fig. 28.)

Sexradiée, a name applied to that variety of the staurotide, composed of three prisms, which cross in such a manner, as to exhibit the six radii of a regular hexagon.

Cruciforme, a name applied to a variety of the harmotome, composed of two prisms, intersecting each other, and producing a kind of cross (Plate IV. fig. 5.)

Triglyphe, when the striæ on the surface of

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* For an account of hemitrope crystals, see p. 72. A crystal of tin is represented Plate V. fig. 18.; and of transposed sulphuret of zinc, Plate V. fig. 4.

the crystal, being viewed on three faces, which unite about the same solid angle, have three different directions, all perpendicular to each other. Thus fer sulfuré (sulphuret of iron) triglyphe (Plate V. fig. 6.)

Géniculé, when the crystal consists of two prisms, which unite at one extremity, so as to form a kind of knee. Thus titane oxidé (red oxide of titanium) géniculé (Plate IV. fig. 35.)

CHAP. VIII.

On the Classification and Arrangement of Minerals according to their most important Physical Properties. — A compendious and certain Method of discovering true from false Gems, and of distinguishing different species of Gems from each other.

F. YOU have said, that mineralogy may be studied either as an art or a science; leaving therefore for the present the scientific arrangement of minerals, I wish to learn, if possible, a compendious mode of discovering the name of any mineral specimen I may find, in order to consult some system of mineralogy, in which its properties and natural history are described. Suppose I have ascertained all the characters of a mineral, according to the method you have described, will this direct me to the name of the species in any systems of the Wernerian school?

B. I am obliged to say it will not; for I am not acquainted with any classification of minerals extant, founded on these characters. Suppose your mineral is an earthy one, you may run through all the species in that class, and be completely bewildered in comparing the characters with those of your specimen.

F. What can have given rise to this defect in the Wernerian system of mineralogy?

B. It would be uncandid to deny, that the defect may partly arise from the difficulty of the subject; but perhaps the want of a classification according to the leading physical characters, is principally owing to a want of courage in the disciples of the German school. They were unwilling to acknowledge, that the Wernerian method was rather an art than a science; for this must have been evident, had they classed minerals according to their external characters. In the classification of Werner, the arrangement is in a great measure chemical, and there is not one external character made use of, to designate any of the genera or families into which they divide the classes. This defect has, I think, hitherto greatly abridged the utility of the Wernerian mineralogy. I have before said, that chemistry and crystallography must form the basis of scientific mineralogy; but for practical use, an arrangement according to the physical characters is required, in order to discover to what species any mineral possessing certain of these characters belongs; hence it appears that we should have two systems, one artificial, and the other scientific; the first, to enable us to refer a mineral to any known species, and to ascertain its name; the second, to enable us to class minerals according to their composition and structure, and to refer them to their true situation in the system of natural bodies. An artificial system is particularly necessary with respect to the class of earthy minerals, their composition being at present imperfectly known.

F. How many species are there belonging to this class?

B. Some mineralogists enumerate more than 150, exclusive of sub-species and varieties. The principal of these I shall arrange in a Table according to their most important characters, to serve the office of a guide in an unknown country, and direct you to the name of the species.

F. What are the characters that you shall select for such an arrangement?

B. Those which are the least variable, and are most easily ascertained with correctness, namely, the SPECIFIC GRAVITY, and HARDNESS; an arrangement of minerals according to these characters conjointly, will indeed be artificial, but if it render you essential assistance in your researches, you need not stop to inquire, whether it be scientific, or empirical.

F. How will you arrange earthy minerals from the specific gravity?

B. Into three orders; in the first, I shall place all those whose specific gravity exceeds three; in the second, the earthy minerals whose specific gravity exceeds two; in the third order, the earthy minerals whose specific gravity is under two.

F. What will be the advantage of such an arrangement?

B. The earthy minerals which we have stated to be about 150, being classed under three leading divisions, when you have discovered to which of these any mineral belongs (see Instructions for taking the Specific Gravity, chap. ii.), your research will be limited within narrower bounds, and you may then proceed to try the mineral in question, by the other character, that of hardness. But in order to derive all the advantage possible from the specific gravity, we may conveniently divide the minerals in each order, into two sections, by placing the heaviest minerals in the upper part of the series, as under:

1st Order.	Sp. Gr.	above 3½. above 3.
2d Order.		above 2½. above 2.
3d Order.		under 2, lighter than water.

F. By weighing the mineral hydrostatically, and consulting the table in which the earthy minerals are arranged according to their specific gravity, I perceive, that I shall be making an approach towards the discovery of its name. If a party of 150 men were divided into six troops, my search for an individual would be materially facilitated, by discovering in which of these troops he was placed: but how am I to proceed to ascertain the hardness of minerals with the greatest ease and precision?

B. By trying them with some well-known mineral, whose hardness is permanent *; but before you proceed to this, it is necessary to remark, that an introductory treatise on any science, always assumes that the reader has a certain degree of preparatory information. The names and positions of the constellations and fixed stars, cannot be discovered by the young astronomer, until a few of the more conspicuous stars have been pointed out to his notice. To obtain a knowledge of mineralogy, it is in like manner necessary, that the learner should be already acquainted with some of the more common minerals, to serve as standards of comparison; and as he proceeds, he will derive the greatest advantage from inspecting well-arranged cabinets whenever he has the opportunity.

F. What minerals are used to try the hardness of other minerals, and what are the minerals with which the learner should be first acquainted?

B. The minerals employed to ascertain the relative degrees of hardness are, quartz, felspar, fluor-spar, and calcareous-spar. Window-glass, though an artificial substance, is also

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* See p. 40 to 42.

very useful as a standard of comparison.* You should be well acquainted with the most common varieties of the above minerals, and also with crystalline and common lime-stone, hornblende, mica, talc, and clay-slate; as these minerals, either alone or combined, form the greater part of the solid substance of the globe, and the rarer minerals are frequently imbedded in them.

F. How many degrees of hardness can be conveniently employed?

B. In some of the divisions we may have five degrees of hardness; but the lighter minerals have a more limited range, none of them being very hard.

This arrangement of the earthy minerals, according to their specific gravity and hardness, will separate them into about twenty well-marked divisions. Having correctly ascertained the degree of hardness and density of any earthy mineral, you will immediately be enabled to discover to which of the divisions it belongs; and the other most obvious and common properties, which are placed in the Table after the name of each mineral, may assist you to ascertain the name and species of the mineral you are examining; but should any doubt remain, you may

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* For trying the hardness of the precious stones, a piece of corundum should be used; this will scratch all other species of minerals, except the diamond. Fragments, or imperfect pieces of almost all the gems, may be obtained at a small expense from the lapidaries.

refer to the description of the natural history and characters of each species, as given in Book II. (See the Index at the end of the volume.)

F. I perceive how greatly the labour of discovering the name and species of any mineral will be abridged by this arrangement; instead of searching for the characters of all the 150 species belonging to this class, I suppose I should rarely have more than ten or twelve species to examine in any of the divisions.

B. The two first divisions are as numerous as any, containing together more than twenty species and remarkable varieties. These divisions include all the most valuable precious stones, except the emerald and the beryl; and it is well worthy of attention, that in these divisions, the characters of specific gravity and hardness are definite in proportion to their utility. For by these characters; any man of plain common sense, who had never seen a gem of any kind, would be able to discover true from artificial gems; and he might by the same means distinguish different species of gem from each other.*

F. Cannot artificial gems be made of the same specific gravity as natural ones?

B. Yes; artificial gems may be made equal in density or specific gravity to any real gem, by

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* By gems are to be understood all precious stones employed in jewellery. The word gem is sometimes used in a restricted sense, to designate engraved-stones or Cameos.

means of metallic oxides; but they cannot be made to equal them in hardness. No artificial gems will scratch quartz: thus you will find, that the two characters, specific gravity and hardness taken together, are sufficient to enable any one to distinguish true from false gems. Frequently, however, real gems of inferior value are fraudulently sold for gems of greater value; for the colour of some gems may be entirely discharged, and of other gems changed by a greater or less degree of heat; and when they are cut, polished, and set, it is difficult to detect the fraud.* It may be useful to recollect, that the two most valuable gems are the hardest. The diamond will scratch every other mineral, and the sapphire will scratch all minerals but the diamond. It has, however, long since been discovered by jewellers, that the angles of primitive crystals are harder than the other parts of the same crystal.

F. Where the specific gravity and hardness of several species in the same division are nearly the same; or where these characters are in some degree variable, the difficulty of distin-

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* The diamond is sometimes green, red, or blue, &c. and almost every species of gem occurs native of various colours; hence the colour cannot be relied on, as a distinctive character. There are, however, properties peculiar to certain gems, which will distinguish them when they are cut and mounted; these will be particularly noticed in the description of each species.

guishing one species from another must be greatly increased.

B. Yes; but fortunately these minerals are for the most part bulky; and we can break off a small piece without injuring the specimen, in order to ascertain the chemical characters of fusibility by the blow-pipe, or solubility in acids. In Table I. I have endeavoured to place immediately before the eye the more obvious properties of each species, or the resemblance to any well-known substance, which may most readily lead the student to discover the name of the mineral he is examining. I flatter myself that you will find this Table of great use when removed from the opportunity of obtaining personal instruction, or of inspecting well-arranged collections of minerals. I propose, however, to give you another arrangement of earthy minerals, more accordant to a natural system, in which those minerals will be classed together that are most nearly allied.

F. What am I to understand by the alliance of minerals?

B. Those minerals that are composed of nearly the same ingredients, — that are frequently found together in nature, — and that often seem to pass by gradation into each other, — may be said to be naturally allied. By arranging such minerals together, we may give a concise natural history of a whole group, which will save much useless repetition in describing their localities and properties. It must be confessed, however, that little is accurately known of the composition of several minerals, and a natural arrangement of them must therefore be incomplete. I shall mark such minerals as indeterminate.*

As a natural arrangement of minerals must be chemical, I shall enumerate all the known elementary constituent parts of minerals; every one who would be a scientific mineralogist should be well acquainted with these elementary substances, and he can be at no loss to obtain this information from many of the valuable systems of chemistry that have been recently published.

F. You have said nothing of the arrangement of the saline, metallic, and combustible minerals.

B. Every intelligible arrangement of the minerals in these classes, must, to a certain extent, be founded in chemistry; I shall, however, make use of the physical properties, particularly specific gravity and hardness, wherever they are of any avail; but I must defer the arrangement of these minerals, until we treat of each of the three classes.

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* In the Greville Collection of Minerals at the British Museum, a very judicious arrangement of the earthy minerals has been made by Mr. Konig, according to their natural alliances; and as that Collection is open to the inspection of the public, I shall frequently refer to it; such references will, it is believed, be particularly acceptable to many persons who have the opportunity of visiting that collection.

CHAP. IX.

A summary View of the elementary constituent parts of Minerals, and their Modes of Combination in the Mineral Kingdom.

B. FROM the preceding view of the mineralogical systems of Werner and Haüy, it is obvious that though the one may make us acquainted with the physical properties of minerals, and the other with their structure and crystalline forms; it is chemistry only which can teach us their real nature, by ascertaining what are the elements of which they are composed, and the manner and proportions in which these elements are combined.

F. If this be the case, would it not be more advantageous to confine the attention of the mineralogist exclusively to the analysis of minerals?

B. A knowledge of the characters of minerals should precede their analysis; for before analysing a mineral, you ought to know whether it be really of the species you wish to examine; or if you would verify the analysis of any preceding chemist, you must be certain that you are operating on the same mineral of which the analysis is given. You can only ascertain this by a previous knowledge of mineralogy, derived from the physical properties and structure of minerals.*

An acquaintance with the leading principles of chemistry is, however, absolutely necessary for those who would obtain a scientific, or even a useful knowledge of minerals. Without any knowledge of chemistry you may indeed become a skilful collector of minerals; but you can have no claim to be considered as a mineralogist. "The former," says Berzelius, "merely seeks a name for his minerals; the latter endeavours to become acquainted with their nature." In our previous conversations, I have taken it for granted that you are well acquainted with the elements of chemistry; for without this know-

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* A small work of the celebrated Swedish chemist, Berzelius, is entitled "An Attempt to establish a pure scientific System of Mineralogy by the Application of the Electro-chemical Theory, and the Chemical Proportions." — He has given the analysis of several minerals, and endeavoured to establish it as a principle, that the earths combine with each other in such proportions, that the oxygen of the one earth is always in a certain ratio to the oxygen of the other; the lesser quantity being one-half, one-third, or some other multiple, or sub-multiple of the greater; the one earth is therefore electro-positive with respect to the other, and they unite as an acid to its base. The present state of chemical science is far too imperfect to enable us to complete such a system.

ledge I consider the study of mineralogy as useless.

F. I will thank you to enumerate all the substances that form the constituent parts of minerals, beginning with those elementary substances that sometimes occur in the mineral kingdom, nearly pure, and in a concrete state.

B. The latter are not numerous. They are,

Carbon	in the Diamond
Sulphur	Native
Gold	Native
Silver	Native
Platina	Native
Palladium	Native
Mercury	Native
Copper	Native
Iron	Native
Antimony	Native
Bismuth	Native
Arsenic	Native.

These are all the elementary mineral substances hitherto found uncombined; for since the discovery of the metallic nature of the earths, the chemist can no longer regard them as elements, but as metallic oxides, or unknown bases combined with oxygen; yet as the basis of the earths never occur in nature in an uncombined state, the mineralogist may still speak of the earths as simple substances. The thirteen simple substances before enumerated, are also frequently combined with other elementary substances.

The whole of the elementary constituent parts of minerals at present known are not fewer than fifty; they comprise twenty-eight metals, the bases of ten earths, and of three alkalies, with nine other elementary substances, as given below:

METALS.

		Sp. Gr.
Malleable	Platina	23.00
	Gold	19.36
	Silver	10.50
	Mercury	13.57
	Lead	11.35
	Copper	8.80
	Tin	7.29
	Iron	7.60 to .80
	Zinc	7.00
	Cadmium?	8.75
	Nickel	8.27
	Palladium	11.8
Brittle and easily fusible	Bismuth	9.82
	Antimony	6.70
	Arsenic	8.31
	Tellurium	6.11

	METALS.	Sp. Gr.
Brittle, and fuse with great difficulty.	Cobalt - -	7.70
	Manganese - -	6.85
	Molybdena - -	7.40
	Tungsten - -	17.33
	Titanium - -	——
	Tantalium, not reduced to a metallic state	
	Chromium - -	5.90
	Rhodium - - -	11.00
	Iridium - - -	19.95
	Osmium - - -	——
	Uranium - -	8.10
	Cerium* - - -	——

BASES OF THE EARTHS.

Of Silex	or	Silicium
Alumine		Aluminum
Lime		Calcium
Magnesia		Magnesium
Barytes		Barytum
Strontian		Strontium
Zircon		Zirconium
Glucine		Glucinum
Yttria		Yttrium
Thoria		Thorium.

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* Two recently-discovered substances, called Wodanum and Selenium, are at present too imperfectly known to be classed with metals. Selenium, according to Berzelius, seems nearly related to sulphur.

BASES OF THE ALKALIES.

Of Potash	or	Potassium
Soda		Sodium
Lithia		Lithium ?

ELEMENTARY SUBSTANCES.

Oxygen
Hydrogen
Azote or nitrogen
Chlorine
Carbon
Sulphur
Phosphorus
Basis of fluoric acid
Basis of boracic acid
Bases of the succinic and mellitic acids unknown.

F. I perceive the elements of which minerals are composed, comprise nearly all the known elementary substances in nature. If many of these elements are combined in one mineral species, the analysis must be attended with great difficulty.

B. Few mineral species contain more than five or six elementary constituent parts. Of the elements above enumerated many have little or no affinity for each other, and are never found together. Others are very commonly united in well-known binary compounds[*]; and when the chemist has obtained these in his analysis, he need proceed no further, as the nature and definite proportions of the elements in each of the binary compounds are already known.

F. I will thank you to explain this more clearly.

B. Suppose then we analyse common gypsum or sulphate of lime. We shall find it is composed of sulphuric acid, lime, and water. We have nothing more to do than to ascertain the proportions of each in one hundred parts, and the analysis is complete, as under:

Lime - -	32.7
Sulphuric-acid -	46.3
Water - -	21.
	100

Here we have three substances, each of which are well-known binary compounds; lime consists of calcium and oxygen; sulphuric-acid of sulphur and oxygen; and water of hydrogen and oxygen. Were we to obtain the elementary parts, the final result would be calcium, sulphur, hydrogen, and oxygen.

F. What are the binary compounds that most frequently occur in the mineral kingdom?

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[*] Binary compounds in chemistry are those substances which are composed of two elements or constituent parts.

B. First, the earths and fixed alkalies, which, as we have before stated, are composed of certain bases, united with different definite proportions of oxygen, next water, and lastly, the acids. They may all be briefly enumerated.

BINARY COMPOUNDS.

Ten earths composed of oxygen and peculiar bases (see p. 178.)

Three fixed alkalies composed of oxygen and peculiar bases (see p. 179.)

Water, composed of	Oxygen and	Hydrogen
Sulphuric acid	Oxygen	Sulphur
Nitric acid	Oxygen	Nitrogen
Carbonic acid	Oxygen	Carbon
Phosphoric acid	Oxygen	Phosphorus
Boracic acid	Oxygen	Boron
Tungsten acid	Oxygen	Tungsten
Chromic acid	Oxygen	Chrome
Molybdic acid	Oxygen	Molybdena
Arsenic acid	Oxygen	Arsenic
Muriatic acid	Hydrogen	Chlorine
Fluoric acid	Hydrogen?	Fluorine
Ammonia	Hydrogen	Nitrogen

Beside these, there are the Succinic acid from amber, and the Mellitic acid, from the mineral called honey-stone: the nature of these acids is at present unknown.

F. As I perceive oxygen is one of the elements in nearly all the above binary compounds, is it invariably united in certain definite proportions in each?

B. Yes; the law of definite proportion is now satisfactorily ascertained, and this discovery, for which we are principally indebted to our own countryman, Mr. John Dalton, author of the "New System of Chemical Philosophy," may be regarded as the greatest step which chemistry has ever taken towards its perfection as a science. Some bodies do indeed admit of combinations with two or more different proportions of oxygen; but these proportions bear a certain ratio to each other, and are definite. The chemist, when he has ascertained the quantities of the above binary compounds, may, therefore, regard his analysis as complete, their nature and constituent parts being known.

F. It appears that oxygen is the most abundant element in the mineral kingdom.

B. It may be said to form a great portion of the globe itself, and of the fluids that float on its surface. It composes three-fourths of the ocean, and of all lakes and rivers, one-fourth of the atmosphere, and more than one-half of the most abundant earth, silex. It forms a large proportion of the other earths and the alkalies, and exists in greater or less quantities in many of the metallic ores, and is combined with almost all other elementary substances in nature.

F. It is remarkable, that oxygen which occupies such an important place in the constitution of the globe, should no where occur in a concrete state. Have we any better ground for believing in its existence, than the former chemists had for believing in the existence of phlogiston?

B. We might fairly doubt its existence were it not that a substance, possessed of all the properties we ascribe to oxygen, does occur in a gaseous state, and increases the weight of bodies with which it combines, whereas the imaginary substance, called phlogiston, whenever it was supposed to combine with other bodies, appeared to diminish their weight. In the present state of chemical science, we are warranted in believing, that one half of the matter of the globe itself consists of oxygen in various forms and combinations; and were science further advanced, we should probably discover, that the remaining half of the globe is also composed of one elementary substance, or hydrogen. There is reason to believe, that hydrogen forms a component part of the metals and of all combustible bodies, nor is it very improbable, that it may form the basis of all the ponderable matter of the globe, combined with oxygen in different proportions; and hence possessing various properties and different electro-chemical affinities. Should such a discovery be made, the various changes that take place in the mineral kingdom will admit of an easy explanation, whenever some future Boscovich shall arise to calculate the reciprocal action of the particles of matter in their different combinations. The chemist also may then hope to obtain that empire over nature, which shall enable him to form the most precious productions of the mineral kingdom from their simple elements. For the present, however, we must content ourselves with the humbler task of exploring the deep recesses of the earth for her mineral treasures, and discovering their nature and properties by patient and persevering investigation.

F. How are the elementary or constituent parts of minerals distributed in the mineral kingdom?

B. The Earths, as the name indicates, form the principal part of earthy minerals, sometimes nearly pure, but more frequently in combination either with other earths or with alkalies, and not unfrequently with acids. The metallic matter in earthy minerals, as we have before observed, may generally be regarded as an accidental admixture. — Of the earths, silex, alumine, lime, and magnesia, are by far the most common in all simple minerals, and also in aggregated masses or rocks; silex being the most and magnesia the least abundant of the four.

Siliceous and aluminous earths are most frequently combined with other earths, and with the alkalies, potash, and soda; but the proportion of the latter is in some instances so small, as to make it doubtful whether they are essential parts, or only accessaries.

Lime is generally combined with carbonic or sulphuric acids; and sometimes, though rarely, with some of the other acids, particularly the fluoric and phosphoric acids. It is also frequently combined with magnesia, but more sparingly with the other earths.

Magnesia is sometimes combined with silex and alumine, but most abundantly with lime.

Barytes and strontian are found principally in veins or nodules, and are of rare occurrence compared with the preceding.

Zircon exists in the minerals called hyacinth and zircon.

Glucine occurs in the emerald, beryl, and euclave, and a few other minerals.

Yttria occurs in a few rare minerals, and combined with the new earth thoria.

The Metals exist in nature either native or combined with other metals, forming alloys, or combined with sulphur, with oxygen, with acids, with water, and sometimes with carbon and with the earths: in these combinations, they are called ores. Not unfrequently two or more metals in combination with sulphur, oxygen, &c.

exist together, forming one species of ore. Of the metals, iron is by far the most abundant, as well as the most useful; it occurs in a great number of earthy minerals, and may be said to form one of the principal constituent parts of the globe; for next to silex, alumine, and lime, iron combined with oxygen and water is one of the most plentiful substances in nature.

The Alkalies form the bases of the salts, and occur in some of the earths. The newly-discovered alkali, lithia, has hitherto been found only in two minerals.*

Oxygen in combination exists both in earthy, saline, and metallic minerals.

Hydrogen, in combination with sulphur, exists in a few earthy minerals; and in combination with carbon, it forms the various bitumens. As a constituent part of muriatic acid, it occurs with chlorine in some metallic minerals.

Azote occurs, as the constituent part of nitric acid and of ammonia, in some of the salts.

Carbon is very abundant in one of the earthy minerals; lime-stone, being combined with oxygen, in the state of carbonic acid, which acid exists in lime-stone in the proportion of 43 *per cent.* forming nearly one half of its substance.

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* Some of the salts, or those substances which have a sapid taste, and are soluble, have metallic bases, consisting of metallic oxides, combined with acids; these metallic salts are not abundant in nature; they will be classed hereafter with salts.

Carbon composes the entire substance of the diamond; it is also nearly pure in graphite or plumbago; and in combination with hydrogen, it forms the various liquid and solid bitumens; such as naphtha, petroleum, and coal.

Sulphur, in combination with oxygen, forms sulphuric acid, which exists combined with many of the earths and alkalies, composing insoluble earthy minerals, and soluble salts. Sulphur occurs combined with metals, and is found native in the vicinity of volcanoes, and occasionally in other situations.

Phosphorus has not hitherto been found native in the mineral kingdom, but combined with oxygen, in the state of phosphoric acid. It occurs united with lime, and with some of the metals.

The Fluoric acid contains a base, the nature of which is but imperfectly known. This acid is combined with lime, in fluor spar: it occurs also in a few other minerals. *

The Boracic acid is also composed of a base which has not hitherto been found in a separate concrete state in nature. This acid occurs combined with soda, and also exists in a few other minerals.

The Succinic acid is a constituent part of amber, and the Mellitic of the mineral called honey-stone.

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* The new earth thoria is found in the fluate of yttria.

F. From what you have previously stated, I may infer that the earthy minerals will be the most difficult to arrange according to their constituent parts, as we are not in all cases certain which of the earths or alkalies are essential ingredients, and which are accidental admixtures.

B. Though this uncertainty prevails in many earthy minerals, yet when we find any species composed principally of one or two of the earths, we may fairly regard these earths in such cases as essential, and arrange minerals according to those prevailing ingredients. We shall hereby generally class together those minerals that are the most nearly allied in their physical properties, and we may leave a more perfect arrangement to be completed in a more advanced state of chemical science. — See Book II. Table II.

CHAP. X.

A general View of the Structure of the Globe, and of the different Mineral Repositories.

The various minerals hereafter to be described compose the solid external part of the globe, and we may infer that the internal part is composed of similar materials to a considerable depth, as the substances ejected by subterranean fires, are similar in composition to those on the surface. If, therefore, we would take an enlarged view of mineralogy as a science, we must not confine our attention to the specimens in the cabinets of collectors, but examine minerals as they exist in nature.

The perforations of the miner extend to comparatively small depths; but by natural fractures and dislocations of the strata, by the ravines which intersect mountains, and by the action of the sea upon the coasts, we are enabled to investigate the nature, structure, and position of the stony masses that environ our planet, and to discover the peculiar situations in which different minerals occur, and thus lay the foundation of the interesting science denominated geology. It would be foreign to the intention of the present work to pursue this science, and describe at length what is known of the structure of the globe, and the changes its surface appears to have undergone; but it may be useful to take a cursory view of the principal mineral and metallic repositories, in order to explain the geological situation of minerals. Those who are desirous of obtaining further information on the subject, I must refer to my "Introduction to Geology."

The lower masses of rock, of which the crust of the globe is composed, form beds of vast thickness and considerable extent; they are generally more or less crystalline, and have sometimes a granular, and sometimes a slaty structure. The granular rocks are most frequently composed of two or more crystalline minerals, aggregated together; and in that case rarely or never contain any petrifactions of animals or vegetables. Hence geologists have given to those rocks the name of primary, from the supposition that they were formed prior to the existence of organic life on our planet. These rocks not only serve as the foundation on which the other rocks and strata are laid; but in many parts of the world they appear to have been raised from their original position by some great convulsion, and they form the loftiest mountains and mountain ranges in Alpine districts.

The rocks denominated primary, furnish us with the most durable materials for architecture and statuary; and it is in the veins that intersect these rocks, that many of the most valuable ores are found. These veins vary in width from a few inches to many feet or fathoms; they cut through rocks and mountains, in a direction more or less inclined from the perpendicular, and sometimes extend many miles in length, varying in width in different parts of their range. To what depth they descend is unknown. These veins appear to have been fractures, which have been filled with mineral matter of a different kind to that of the rocks which they intersect. Metallic ores seldom fill the whole width of veins; but the ore is intermixed with earthy minerals, which are called the matrix or gangue. There are frequently hollows or cavities in veins, sometimes filled with water, in other instances empty. It is in the lining of these cavities, that the most beautiful crystallizations in the mineral kingdom are found. It is observed, that some minerals and some metallic ores occur only in the veins of certain rocks, and are never met with in the veins of other rocks. Those who would obtain further information on this subject, I must beg leave to refer to Chap. XII. of my "Introduction to Geology."

The minerals that are found in the situation I have been describing are said to *occur in veins.*

The great masses of primary rocks display no distinct traces of stratification; they are indeed often divided by rents and seams into forms more or less regular, which sometimes appear to be the result of crystallization on a large scale. The rocks that immediately cover the primary, frequently exhibit more distinct traces of stratification; but they are generally less perfectly crystalline than the lower rocks. They contain occasionally some remains of marine animals, and many of them are intersected by metallic veins.

In primary rocks, as well as in some of the rocks by which they are covered, we may frequently observe a comparatively thin bed, formed of one mineral, interposed in the midst of a thicker bed of rock of another kind. Thus a bed of lime-stone may frequently be found in a rock composed of slate, similar to roofing-slate. Iron and some metallic ores occasionally form beds in mountains; when this is the case, they are said to *occur in beds*, which is intended to distinguish their position from that of the ores, which occur in veins.

If we suppose a number of volumes of the same work laid upon each other, and a volume of another work introduced between them, it will represent the position of a mineral bed. *

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* We must be careful, however, to distinguish between a mineral occurring in beds and being *imbedded*. In the latter

The rocks that cover those we have describing, are arranged in regular layers of various degrees of thickness, or, in other words, are distinctly stratified. The position of the layers or strata is more horizontal than that of the lower beds; they frequently contain numerous organic remains of marine animals or vegetables. The marine animal-remains principally occur in lime-stone strata, and the vegetable-remains in sand-stone or in argillaceous strata. It is among the regular argillaceous and sand-stone strata that beds of coal and iron-stone are most generally found; but these strata rarely contain any kind of metallic veins. (See Introduction to Geology, chap. viii.)

The uppermost regular strata, generally consist of lime-stone, or beds of sand and indurated clay, and contain marine organic remains, but of different species from those in the lower strata. It is in these strata, that bones of vertebrated animals, or such as had a brain and spinal marrow, first occur. Over the regular strata, we find thick irregular beds of clay, sand, or gravel, evidently formed from the ruins of pre-existing rocks or

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case, crystals or small masses of a simple mineral, are buried in another mineral substance like plums in a pudding. Metallic ores, particularly of gold and silver, sometimes exist in small masses, imbedded in, or disseminated through entire rocks.

strata, that have been washed down and spread over valleys, or form the beds of rivers. These depositions are called *alluvial*. In some *alluvial depositions* from Alpine districts, metallic ores and other minerals occur in the form of pebbles and grains. These minerals doubtless existed in the rocks, from whose disintegration the alluvial deposits were formed. To obtain these metallic grains, the sands of rivers and of the sea-shore are sometimes washed and explored with the greatest care; large quantities of tin are obtained in this manner from the sands of rivulets, or on the coast in Cornwall, the tin-ore from these deposits is called stream-tin. A great part of the gold from Africa, and the gold and diamonds in the Brazils, is obtained in a similar manner from the sands of rivers.

Beside the rocks we have been describing that occur in succession over each other, there are other rocks of vast extent, which have been formed by volcanic fire, the materials of which they are composed having been poured out of openings in the earth in a melted state, and spread over a greater or less extent of country. When the fluid-matter becomes consolidated, it forms immense rocks of vitreous, stony, or porous lava; these rocks of lava are often covered by other beds from succeeding eruptions, and thus compose mountains of immense size and height. This kind of formation is now taking place extensively in various parts of the world, particularly in the Northern, Pacific, and in the Indian ocean. We may also observe, in most countries, that the strata are often broken through and covered by vast beds and masses of rock, greatly resembling lava both in composition and appearance; hence we may infer, that subterraneous fire has, in former ages, acted extensively on the surface of our present continents, and has occasioned those successive alternations and changes to which they appear to have been subjected. These rocks resembling lava are known by the names of basalt, trap, and porphyry. Neither in these rocks, nor in volcanic rocks, do we often meet with regular metallic veins, though metallic minerals sometimes occur in them.

There is another kind of rock formation taking place at the present time, from the earthy matter held in solution by water, and deposited either in the beds of rivers, at the bottom of lakes, or in the hollows of caverns. These beds have received from mineralogists the name of *tufas* and *sinters*; and the mineral depositions of this kind in caverns, are commonly called *stalactites* and *stalagmites*. These depositions sometimes consist of calcareous, and sometimes of siliceous earth; but most frequently of the former.

In the mineral kingdom, particularly in the upper strata, we frequently meet with minerals that have taken the distinct forms of animals or vegetables. In some instances, the most delicate organic fibres may be traced, but they are converted into a substance in every respect similar to flint, in other situations this substance is lime-stone. These mineral forms of organic life, are called *extraneous-fossils* and *petrifactions*.

For a long time naturalists doubted, whether these fossils were the real remains of organized beings, or were to be regarded as *lusus naturæ*. Tournefort, from the regular forms of many of these organic-remains, was induced to believe that they were stones that grew and vegetated from seeds. " How should the cornu ammonis," says he, " which is constantly in the figure of a volute, be formed without a seed containing the same structure in the small as in the larger forms ? Who moulded it so artfully, and where are the moulds ?" This opinion serves to show how little attention had been bestowed at that time on the mineral kingdom.

Naturalists and geologists no longer doubt, whether these *extraneous-fossils* owe their forms to organic life; as it is discovered, that most of them contain some trace of their original animal or vegetable matter, and others still retain a considerable part of their original elements. Some of these extraneous-fossils are, however, only casts or impressions of plants or animals, the mineral matter having filled up the cavities of shells, or the hollows in rocks, where the organic remains once existed. This circumstance seems to indicate the manner in which animal or vegetable substances have been apparently converted into stone; for in the case of casts or impressions of plants or animals, we may suppose, that the cavities were filled by the infiltration of water, holding the earthy matter in solution, and gradually depositing its contents. In the same manner, when the parts of animals or vegetables appear changed into stone, we have only to imagine a much slower and more delicate process, by which the particles of silex or lime were deposited in the direction of the fibres, as the organic matter was removed. In most cases, the earthy depositions have enveloped and preserved a portion of the fibres themselves. It may be worthy of remark, that these organic-remains appear for the most part to be the relics of species of animals or vegetables not now existing on the globe; but the study of these remains is the proper department of the zoologist, the botanist, or the geologist; extraneous-fossils cannot find a place among mineral species.

It remains to be observed, that minerals, when first obtained from their natural beds, are commonly softer, and break with greater facility than when they have been exposed to the air, Many of the most compact minerals contain a minute portion of water in their pores, and a kind of dew may be seen on the surface of a fresh fracture when they are recently extracted from their native situations; this, as M. Patrin observes, is the case with flint. Almost all minerals that occur near the surface of the earth, and are exposed to the action of water and change of temperature, undergo decomposition, and many, even of the harder minerals, may be found in such situations more or less changed. The mineralogist in selecting specimens for examination, must therefore take care that they are perfectly sound, otherwise their characters may be so altered as to make it difficult, if not impossible, to ascertain to what species they belong. An incipient state of decomposition is often indicated, by a change of colour or lustre in minerals that appear in other respects unchanged.

AN

INTRODUCTION

TO

MINERALOGY.

BOOK II.

NATURAL HISTORY AND CHARACTERS OF EARTHY-MINERALS.

Essential Characters.

Insoluble in water and insapid.	These characters distinguish earthy minerals from saline.
Incombustible at a white heat.	This character distinguishes earthy minerals from all combustible minerals.
Specific gravity under five.—Destitute of true metallic lustre. — Not reducible to a metallic state, nor volatilized at a high temperature before the blow-pipe.*	These characters taken collectively distinguish earthy from metallic minerals.

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* A very few earthy-minerals have a lustre, which is called false or pseudo-metallic, as it is destroyed by cutting the surface with a knife, which is not the case with minerals that have the true metallic lustre.

NOTICE TO THE READER.

The following Classification of Earthy Minerals, according to their two most permanent and important Characters, Hardness and Specific Gravity, is the first attempt of the kind which the Author is acquainted with to make these Characters, conjointly, the basis of a Synoptical Arrangement, intended to direct the Student to the names of Minerals.

The degrees of hardness possessed by different minerals, as stated in the following tables, vary in many instances from those of preceding writers. Where this is the case, the author has given the results of repeated trials, in which he was obligingly assisted by Mr. Lowry, of Titchfield-street, whose valuable collection of minerals, furnished ample materials for such experiments.

It has been too generally admitted, when one mineral will slightly cut or scratch another, that it possesses a superior degree of hardness, whereas two minerals, having the same degree of hardness, will reciprocally cut each other.

In the Table No. 1. *some of the most obvious characters are annexed to each Mineral, and the resemblance to any well-known natural or artificial substance is added where it could conveniently be given; the main intent of the Table being to direct the student to the names of the minerals he is examining.*

In the description of Mineral Characters in the present volume, by the prevailing Form or Colour, is meant the Form or Colour which most frequently occurs in the Species.

Minerals are said to occur crystallized, not only when they are found in perfect geometrical forms; but also when some of the faces of the crystals are visible, and the others are concealed or imperfectly formed.

Minerals are said to be amorphous *when they have no definite external form. The term amorphous having no relation to the size, is less liable to ambiguity than the term massive. The term massive is sometimes used in the following descriptions, when uncrystallized minerals occur in masses or beds of considerable size.*

Massive or amorphous minerals may have an internal arrangement of the parts called the structure, which may be either laminar, fibrous, *or* granular; *or they may be internally* earthy, *like chalk; or* compact, *without any discernible parts, like flint.*

As lamina, or laminæ plural, are employed in crystallography to designate the thin plates of which crystals are composed, the term laminar is used, in the present volume, in describing the structure of minerals. Where a number of laminæ form a thick plate, the term lamellar is employed.

A

TABULAR ARRANGEMENT

OF

EARTHY MINERALS,

ACCORDING TO THEIR MOST ESSENTIAL PHYSICAL PROPERTIES, SPECIFIC GRAVITY, AND HARDNESS.

ORDER I. SPECIFIC GRAVITY exceeding three.
§ *a.* *Sp. Gr. exceeding three and a-half.*
§ *b.* *Sp. Gr. exceeding three.*

Division 1. Harder than Quartz, scratch Quartz with ease.
2. Rather harder than Quartz, scratch Felspar with ease.
3. Hardness about equal to Felspar, scratched by Quartz, scratch Window-glass with ease.
4. Softer than Felspar, scratch Fluor-spar, or Window-glass feebly.
5. Softer than Fluor-spar.

ORDER II. SPECIFIC GRAVITY exceeding two and a-half.

Division 1. Hardness rather exceeding Quartz, or nearly the same, not scratched by Quartz, scratch Felspar.

Division 2. Hardness about equal to Felspar, scratched by Quartz, scratch Window-glass with ease.
3. Softer than Felspar, scratch Fluor-spar.
4. Scratched by Fluor-spar.

ORDER III. SPECIFIC GRAVITY under two and a-half.

Division 1. As hard as Quartz, scratch Felspar.
2. As hard as Felspar.
3. Scratched by Felspar, scratch Window-glass and Fluor-spar.
4. Softer than Fluor-spar.

ORDER IV. SPECIFIC GRAVITY under two.

Division 1. Harder than Flour-spar.
2. Soft, yield to the Nail.

Table I.—EARTHY MINERALS.

Order I. *Division* 1. Harder than Quartz, scratch Quartz with ease.

Specific Gravity exceeding 3½.

Sp. Gr.		
4.72—4.55	ZIRCON, in grains and crystals, colours various and pale, translucent or transparent; refracts doubly. (Plate III. fig. 30.) Zircon-Hyacinth (fig. 31.), colour orange-red.	
4.23—4.10	PRECIOUS GARNET, blood-red, cherry-red, transparent, in roundish crystals, with twelve, twenty-four, and thirty-six sides (Plate II. fig. 17. Plate IV. fig. 10.)	
4.00—3.87	CORUNDUM, colours various and dull, translucent, amorphous, and crystallized, in six-sided prisms.	
4.20—4.00	Sapphire, Blue -	Crystals sometimes colourless, more or less transparent, six-sided prisms, or acute six-sided pyramids single or double (Plate IV. fig. 18,19.)
4.00—3.97	Red Sapphire -	
4.00—3.91	Yellow Sapphire	
4.00	White Sapphire	
4.20	Green Sapphire	
4.00	EMERY, amorphous, granular, colour blackish and blueish-grey.	
3.79—3.55	CYMOPHANE, grains and crystals (Plate IV. fig. 17.), colour light-green, opalescent, semi-transparent.	
3.94—3.72	PYROPE, deep red, transparent, in grains.	

Sp. Gr.	
3.79—3.76	PLEONASTE, or CEYLANTE, colour nearly black, opaque, in grains and splendent octahedral and tetrahedral crystals.
3.70—3.50	SPINEL-RUBY, prevailing colour red, various, transparent, crystals octahedral and tetrahedral (Plate II. fig. 14, 15.)
3.64—3.55	TOPAZ, prevailing colour yellow, various, in long transparent prisms (Plate III. figs. 39, 40, 41.)
3.55—3.49	DIAMOND, in roundish pieces, grains and crystals, common form octahedral and tetrahedral (Plate I. figs. 14, 15. Plate IV. fig. 29.), transparent, or translucent, colourless, and various shades of grey, also blue, red, brown, and green, scratches all other minerals.*

Specific gravity under $3\frac{1}{2}$.

3.06—2.90	EUCLASE, crystallized, transparent, splendent, refracts doubly, easily frangible, rare.
3.16—3.10	ANDALUSITE, amorphous and crystallized, in four-sided prisms, colours flesh-red and grey.

Division 2. Rather harder than Quartz; scratch Quartz with some difficulty, but felspar with ease.

3.75—3.65	COMMON-GARNET, crystals roundish, with twelve, twenty-four, and thirty-six sides, colours various (Plate IV. figs. 9, 10.)
	BLACK-GARNET, or MELANITE, occurs in lava.

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* The Diamond belongs to the class of combustible minerals.

Sp. Gr.	
3.64—3.60	CINNAMON-STONE, in small yellowish-red transparent pieces or grains.
3.53—3.50	PYCNITE, long six-sided crystals, yellowish, inclining to red.
3.45	PYROPHYSALITE, amorphous, colour dull greenish-white, disengages bubbles of gas before the blow-pipe.
3.35	GROSSULAR, olive-green, crystals like common garnet.
3.44	VESUVIAN (Idocrase), splendent brown or greenish crystals, transparent, occurs in volcanic rocks (Plate IV. fig. 8.)
3.28	STAUROTIDE, (Grenatite), long, dark reddish-brown prisms (Plate IV. fig. 27, 28.)
3.25—3.15	TOURMALINE, green, blue, various, semi-transparent. RED SCHORL, or RUBELITE - - COMMON BLACK SCHORL - - - Crystals six, nine, or twelve sided prisms, deeply streaked, (Plate IV. figs.11,12,13.)
3.25	SAUSSURITE *, *var.* massive, white and greenish, and fusible on the edges.
3.21	SPODUMENE, greenish-white, translucent, imbedded, before the blow-pipe, exfoliates in gold-coloured scales.
3.16—3.10	HAÜYNE, prevailing colour sky-blue, in grains, and garnet-shaped crystals.

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[*] Where the hardness is variable, *var.* is placed after the name of the mineral.

Sp. Gr.	
3.20—3.00	TREMOLITE, *var.* white, in aggregated prisms, diverging or fibrous, lustre pearly.* (Plate IV. fig. 25.)
Division 3.	Hardness about equal to or exceeding Felspar, scratched by Quartz.
4.60—4.26	AUTOMALITE, dark blueish-green, octahedral crystals, opaque, contains oxide of zinc.
4.20	GADOLINITE, greenish-black, lustre splendent, resinous, gelatinous, with acids.
3.44	EPIDOTE, yellowish-green, amorphous, and crystallized, frequently in groups, more or less translucent (Plate IV. figs. 14, 15, 16.)
3.40	CHRYSOLITE, yellowish-green, in grains and crystals, transparent (Plate IV. fig. 20.)
3.39	HYPERSTENE, amorphous, dark-greenish brown or black, with reflections of a semi-metallic copper-red.

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* These divisions comprise all the most valuable gems, except the emerald, the beryl, and chrysolite; they may be arranged according to their relative degrees of hardness, as under:

Diamond.
Sapphire, Corundum, Cymophane.
Zircon, Hyacinth, Spinel = Pleonaste.
Precious Garnet = Pyrope. Topaz = Beryl = Emerald. Euclase? [illegible]
Common Garnet, Melanite? Grossular Cinnamon-stone, Tourmaline, red, green, blue, and black. Vesuvian, Pycnite, Staurotide.

Sp. Gr.	
3.30—3.11	ANTHOPHYLITE, occurs crystallized and amorphous; structure radiated, colour reddish-brown, lustre approaching to semi-metallic.
3.31	ZOISITE, amorphous, and crystallized in four-sided prisms, blueish-grey, translucent.
3.25—3.21	AXINITE, colour violet, dark-brown, in sharp axe-shaped crystals (Plate IV. figs. 6, 7.) lustre splendent, translucent.
3.20—3.14	DIALLAGE, *var.* massive and disseminated, green, lustre pearly, or approaching to metallic.
	BRONZITE, *var.* yellowish, or pinchbeck-brown, lustre approaching to semi-metallic, massive.
3.19	BASALTIC-HORNBLENDE, crystallized in longish prisms (Plate III. fig. 24.) colour velvet-black, lustre splendent, vitreous.
3.04	BLUE-FELSPAR, colour smalt-blue, massive.
3.00	JADE, *var.* massive, light and dark-green, translucent with a greasy lustre, feels rather unctuous.

Division 4. Softer than Felspar, scratch Fluor-spar or Window-glass feebly.

4.00—3.80	YENITE, amorphous, and in rhomboidal prisms, black, lustre vitreous, opaque, fusible.
3.68—3.50	SAPPARE (Disthene and Kyanite), hardness various, sky-blue, in long translucent prisms, generally imbedded in mica-slate.

Sp. Gr.	
3.60	SCAPOLITE, or PARANTHINE, greyish-white and green, amorphous, and crystallized in prisms, translucent, lustre resinous or pearly.
	WERNERITE, grey and green, brown, amorphous, and in four-sided prisms. N. B. A variety of Scapolite.
3.47—23	SAHLITE, amorphous, crystallized, green and grey, translucent, structure distinctly laminar.
3.28	AUGITE, prevailing colour dark-green, crystallized, amorphous, and in grains, often nearly opaque, in volcanic and basaltic rocks (Plate IV. figs. 21, 22.)
3.22	OLIVINE, yellowish-green, in grains, rarely crystallized, translucent, lustre resinous or vitreous, in basalt and lava.
3.20	HORNBLENDE, greenish-black, dark-green, amorphous, and disseminated, imperfectly crystallized in rhomboidal or flat prisms, promiscuously aggregated or diverging, nearly opaque.
	COMMON-ACTYNOLITE, dark-green, promiscuously aggregated, diverging, or radiated.
3.29—3.00	GLASSY-ACTYNOLITE, grass-green, crystallized in acicular prisms, parallel or diverging, translucent.
3.14	SMARAGDITE, massive and disseminated, lamellar, bright green, lustre faint, pearly.
3.08	BASALT, blueish or brownish black, columnar, amorphous, vesicular, finely granular, nearly compact.

Division 5. Softer than Fluor-spar.

Sp. Gr.	
3.19—3.10	FLUOR-SPAR, generally crystallized in cubes, prevailing colour amethystine blue, transparent.

4.50	HEAVY SPAR, SULPHATE of BARYTES, crystallized and massive, yellowish-white and various, lustre vitreous or pearly, transparent or translucent, gives a yellow colour to flame (Plate III. figs. 23, 24, 25, 26.)
4.36—4.27	CARBONATE of BARYTES, greenish or yellowish-white, translucent, generally amorphous, structure approaching to fibrous and diverging, gives a yellow colour to flame.
3.96—3.60	SULPHATE of STRONTIAN, white, inclining to blue and red, lustre pearly, or resinous, transparent or translucent, crystallized and fibrous, gives a red colour to flame (Plate III. figs. 27, 28.)
3.67	CARBONATE of STRONTIAN, greenish-white, amorphous, and crystallized, translucent, gives a red colour to flame.
3.17—3.20	APATITE, crystallized in short six-sided prisms, colours blue, green, and white, pale, lustre between vitreous and resinous.

Order II. Specific Gravity exceeding $2\frac{1}{2}$.

Division 1. Hardness greater than Quartz, or nearly the same, scratch Felspar.

Sp. Gr.	
2.70	EMERALD, colour a bright green, crystals six-sided prisms, fusible.
2.65	BERYL, colour pale green, crystals transparent six-sided prisms, sometimes large, fusible with difficulty.
2.56	IOLITE, violet in one direction, yellowish-brown in another, six-sided prisms, fusible with difficulty.
2.75	ADULARIA, translucent, pearly, white, distinctly laminar (see Felspar).
2.68	PRASE, leek-green, translucent, massive.
2.62	CAT'S-EYE, in rounded pieces, grey and yellowish, chatoyant, translucent.
2.62	CHALCEDONY, blueish-grey, milky, translucent, in rounded pieces and stalactitical.
2.58—2.32	CARNELIAN, prevailing colour blood-red, translucent, in rounded pieces.
2.60—2.70	HELIOTROPE, dark-green, with red spots, or striped yellow, nearly opaque.
2.60	FLINT, dark and light grey or brown, translucent on the edges.
2.62	LYDIAN-STONE, massive, black, opaque.
2.53—2.44	PLASMA, green, translucent (green flint).
2.65—2.58	QUARTZ, crystallized and massive, colourless and various colours, transparent or translucent; colourless quartz resembles glass, crystals generally six-sided prisms, terminated by six-sided pyramids, (Plate III. figs. 32, 33.)

Sp. Gr.	
2.63	HORNSTONE, massive, colours various, dull, nearly opaque, approaches to flint.
2.63	HORNSTONE-SLATE, or FLINTY-SLATE, grey, massive, dull, opaque.
2.63	EGYPTIAN-JASPER, red, yellowish, and brown, lustre glistening, opaque.
2.63	BROWN-JASPER, nearly opaque, massive.

Division 2. Hardness equal to Felspar; scratched by Quartz, scratch Window-glass with ease.

2.92—2.62	PREHNITE, prevailing colour pale-green, translucent, lustre pearly, crystals often in radiated groups, fusible.
2.92	CHIASTOLITE, in long slender quadrangular prisms, white externally, inclosing a darker-coloured prism (Plate IV. fig. 26.)
2.70	CHRYSOPRASE, amorphous, apple-green, translucent.
2.69—2.65	FELSPAR, COMMON, massive and crystallized (Plate III. figs. 2, 34, 35, 36, 37, 38.), prevailing colours white and red, structure laminar, translucent.
	LABRADOR-FELSPAR, smoke-grey, exhibits by reflection a rich play of yellow, blue, and red colours, with a splendent semi-metallic lustre.
	GLASSY-FELSPAR, vitreous.
2.45	PETALITE, purplish-white, translucent, nearly resembles white quartz, fusible.

Sp. Gr.	
2.55	PORCELAIN-JASPER, massive, colour grey and blue, mixed with red and yellow, opaque.
	COMMON-JASPER, red and various, dull, opaque, fracture conchoidal.
	RIBBON-JASPER, colours various, in stripes.

Division 3. Softer than Felspar; harder than Fluor-spar.

2 98	DATOLITE, colour greyish-white, and greenish-grey, translucent, massive, and crystallized, becomes soft, opaque, and white in the flame of a candle, gelatinizes with acids.
2.91—2.51	BORACITE, small crystals (Plate III. fig. 9.), yellowish and greenish white, lustre vitreous, electric when heated.
2.91	ARRAGONITE, crystallized in six-sided prisms, harder than calcareous spar, becomes opaque and friable in the flame of a candle.
2.81	LEPIDOLITE, massive, composed of small scales, purple or pearl-grey.
2.67	NOVACULITE, greenish or yellowish grey, compact, massive, rather unctuous to the touch.
2.57.	CLINK-STONE, colour grey and greenish-grey, compact, massive, yields a metallic sound when struck, easily fusible.
2.71.	CHABASIE, crystals nearly cubical, colour white and greyish, transparent or translucent, fusible.

Sp. Gr.	
2.80—2.70	LAPIS-LAZULI, bright blue, generally massive, nearly opaque, fracture fine-grained, loses its colour in nitric acid.
	AZURITE, indigo-blue, massive, in oblique prisms, laminar, opaque.
2.61	ELAOLITE, or FETSTEIN, massive, greenish or blueish-grey, or brown, lustre resinous, opalescent, gelatinizes with acids.
2.74	INDIANITE, white and grey, massive, granular, rare.
2.60	MEIONITE, in smooth, splendent, small, four-sided prisms, truncated on the edges, translucent, occurs in lava.

Division 4. Scratched by Fluor-spar.

2.94	CRYOLITE, massive, colour greyish-white or brown, becomes liquid before the blow-pipe, and then hardens.
2.95	ANHYDRITE, or ANHYDROUS GYPSUM, crystallized and compact, blueish-white, pearly, becomes glazed on the surface before the blow-pipe.
2.91	MAGNESITE, massive, tuberose, yellowish-grey or white, infusible, dissolves slowly in acids.
2.88	PEARL-SPAR, milk-white and brown, pearly, massive and crystallized, curvedly lamellar, effervesces with acids.
2.83—2.71	GRANULAR LIME-STONE, or STATUARY MARBLE, resembles loaf-sugar, effervesces with acids.

Sp. Gr.	
2.88—2.70	COMPACT COLOURED MARBLE, colours various, compact, effervesces with acids.
2.71	CALCAREOUS-SPAR, refracts doubly, breaks into rhomboids, crystallized (Plate III. figs. 6, 14, 15, 16, to 23.)
2.63	CLAY-SLATE, blueish and greenish grey, massive, structure slaty.
2.65	MICA, in thin laminæ, shining, transparent, flexible, and elastic.
2.91	PINITE, crystallized, in six-sided prisms, blackish-grey or green, surface brown, sectile.
2.88	POTSTONE, sectile, massive, greenish-grey, unctuous.
2.81	AGALMATOLITE, greenish-grey, and various, translucent, sectile, massive.
2.80	TALC, prevailing colour greenish-white, pearly, laminæ transparent, flexible, but not elastic.
2.80—2.60	CHLORITE, green, consists of fine scaly adhering particles, feels greasy.
2.68	ROE-STONE, yellowish-white, massive, contains minute globules imbedded.
2.68	DOLOMITE, finely granular, generally white, resembling very fine loaf-sugar, softer than marble.
2.67	CHALK, white, dull, opaque, earthy.
26.7	ASBESTOUS-TREMOLITE, diverging fibrous concretions, greenish-white.
2.64	SLATE-SPAR, curvedly laminar, white, nearly opaque, pearly, massive, effervesces violently in acids.

Sp. Gr.	
2.59	GREEN-EARTH, green, earthy, feels rather greasy.
2.63	STEATITE, white and greenish-white, sectile, resembles white soap.
2.58	SERPENTINE, green, sometimes red, and various, opaque, dull, compact, massive, feels rather greasy, the green has generally yellow scales adhering.

ORDER III. SPECIFIC GRAVITY under 2½.

Division 1. As hard as Quartz, scratch Felspar.

2.22	WAVELLITE, greenish-white, in mamillated concretions composed of radiated crystals, translucent.
2.27	MENILITE, colours grey and brown, in tuberose pieces, translucent on the edges.
2.27	CACHOLONG, milk-white, compact, pearly, translucent.
2.06	JASPER-OPAL, massive, lustre vitreous, nearly opaque, red and yellow.

Division 2. Hardness about equal to Felspar.

2.49—2.45	LEUCITE, *var.* white, opaque, garnet-shaped crystals in lava.
2.37	SODALITE, light-green, massive, and in garnet-shaped crystals, lustre vitreous or resinous, laminar, infusible.
2.33	HARMOTOME, greyish-white, lustre pearly, in small crystals which sometimes form a cross (Plate IV. fig. 5.)
2.20	NATROLITE, yellowish-white, with circular or curved stripes of brown, amorphous, and in radiated capillary crystals, lustre pearly, fusible.

Division 3. Scratched by Felspar, scratch Window-glass.

Sp. Gr.	
2.47—2.14	HYALITE, resembles gum, adheres to basaltic rocks.
2.40—2.33	OBSIDIAN, or volcanic glass, resembles black glass.
2.48—2.19	PITCH-STONE, dark-green or brown, resinous lustre, resembles pitch.
22.7	PEARL-STONE, greyish-white, pearly, in roundish concretions.
2.27	NEPHELINE, small white translucent six-sided prisms in lava.
2.24	ANALCIME, pale grey, pearly, in cubic or garnet-shaped crystals, generally aggregated (Plate IV. fig. 3.)
2.11	OPAL, a beautiful and sometimes splendent play of colours, translucent, milk-white or yellowish, lustre vitreous.
2.18	SEMI-OPAL, white, yellowish, and various, lustre waxy, translucent.
2.45	APOPHYLITE, white, a splendent pearly lustre, crystallized, exfoliates by heat.
2.20	STILBITE, hardness variable, crystallized, aggregated, diverging, lustre splendent and pearly, prevailing colour white, exfoliates by heat.
2.20 to 2.23	LAUMONITE, *var.* white, pearly, becomes soft by exposure to the air.

N. B. Apophylite, Stilbite, and Laumonite, are sometimes softer than Fluor-spar.

Division 4. Softer than Fluor-spar.

Sp. Gr.	
2.28—2.16	GYPSUM, massive, prevailing colour white, nearly resembles statuary marble, yields to the nail, and does not effervesce with acids.
2.28—2.16	SELENITE, crystallized, transparent, pearly, yields to the nail.
2.21	PORCELAIN-EARTH, white, of various tints, feels soft, but not unctuous.
2.18	CIMOLITE, greyish-white, dull, massive, adheres to the tongue.
2.20	TRIPOLI, grey and yellowish-brown, dull, and nearly fusible.
2.13	MAGNESIA, native, white, massive, pearly, soluble in acids, adheres slightly to the tongue.
2.06	BITUMINOUS-SHALE, deep grey, or nearly black, opaque, slaty.

ORDER IV. SPECIFIC GRAVITY under 2.

Division 1. Harder than Fluor-spar.

1.80	SILICEOUS-SINTER, light grey, brown, porous.
1.80	GLASSY-PUMICE, porous and vesicular.

Division 2. Soft, yields to the nail.

1.72	FULLER'S-EARTH, earthy, dull, soft, falls into a pulpy mass in water.
1.66	SUB-SULPHATE of ALUMINE, white, earthy, nearly friable.
1.90.	MEERSCHAUM, yellowish-white, dull, strongly adhesive, sometimes supernatant.

Sp. Gr.	
1.	ROCK-CORK, slightly elastic, sectile, but tough, white and grey, massive, and in plates, swims in water.
1.	AGARIC-MINERAL, yellowish or greyish-white, soft, tender, opaque, floats for a short time on water.

The following metallic minerals have frequently an earthy appearance; their specific gravity is under 4. They are not reducible to the metallic state by the common blow-pipe, and may be mistaken by the learner for earthy minerals.

Iron-Stone, Clay Iron-Stone, massive.
Black and Brown Hematite, or Oxide of Iron, in nodules, and massive.
Carbonate of Iron.
Black or Brown Oxide of Manganese.
Carbonate of Manganese.
Calamine.
Pharmacolite, volatilized by the blow-pipe, white, soft.

See the characters of each among the class of metallic minerals.

TABLE II.

A

CHEMICAL ARRANGEMENT

OF

EARTHY MINERALS,

ACCORDING TO THE PREVAILING EARTHS IN EACH SPECIES.

ORDER I. SILICEOUS. Silex, or Silex containing Water and Iron, with sometimes a minute Portion of other Earths.

II. SILICEO-ALUMINOUS. Silex and Alumine, with sometimes a Mixture of Iron, or of other ingredients.

III. SILICEO-CALCAREOUS. Silex and Lime, with Iron and other ingredients.

IV. SILICEO-MAGNESIAN. Silex and Magnesia.

V. ALUMINOUS. Alumine nearly pure, or combined with Water.

VI. ALUMINO-SILICEOUS. Alumine and Silex.

VII. ZIRCO-SILICEOUS. Zircon and Silex.

VIII. GLUCO-SILICEOUS. Glucine, Silex, and Alumine.

Order IX. YTTRIO-SILICEOUS. Yttria and Silex with Iron.
X. CALCAREOUS. Lime with Acids.
XI. CALCAREO-SILICEOUS. Lime with Silex.
XII. CALCAREO-MAGNESIAN. Lime with Magnesia.
XIII. MAGNESIAN. Magnesia with Water Acid.
XIV. BARYTIC. Barytes and Acids.
XV. STRONTIAN. Strontian and Acids.

APPENDIX to BOOK II.

EARTHY-COMPOUNDS, AND AGGREGATED ROCKS.

N. B. *In the following Table, Minerals are arranged according to the Earths of which they are principally composed. Those Minerals that contain one Earth, either pure or combined with Water, or colouring matter, or with only a minute portion of any of the other Earths, are placed in separate orders: the Minerals which contain a portion of some other Earth as a constituent ingredient, are also placed in separate orders; and where a third ingredient enters into the composition of a Mineral, in such a proportion that we may regard it as an essential constituent part, it is noticed against the species in which it occurs.*

This arrangement is merely intended to present the learner with a general view of the composition of Earthy Minerals, and to bring together those Minerals which most nearly agree in their principal constituent parts. The analysis of each species, where it is known, is given with the natural history and characters, in the following part of Book II. *Those Earthy Minerals, the composition of which is not known, or is doubtful, are placed as indeterminate, or a mark of interrogation ? is annexed.*

Many rocks admitted into some mineralogical systems, as simple Minerals, may be more correctly described as Earthy Compounds, being in reality composed of different species intimately blended together, or of an admixture of Earths without any definite proportions; these are described in an Appendix as Earthy-Compounds, or as aggregated Rocks.

ORDER I. SILICEOUS.

Sp. QUARTZ. *From 96 to 99 parts Silex.* Page 232

- *Vitreous Quartz*
  - Quartz-Crystal, or Rock-Crystal.
  - Purple-Quartz, or Amethyst.
  - Yellow-Quartz, or False Topaz.
  - Blue-Quartz, or False Sapphire.
  - Red-Quartz, or Hyacinth of Compostella.
  - Smoke-Quartz, or Cairngorm.
  - Green-Quartz, or Prase.
  - Rose-Quartz.
  - Milk-Quartz.
  - Fat-Quartz, or Greasy Quartz.
  - Fœtid-Quartz.
  - Cat's-Eye, or Splendent fibrous Quartz.
  - Granular-Quartz.
  - Massive Common-Quartz.
- *Chalcedonic or Flinty Quartz* -
  - Chalcedony.
  - Carnelian.
  - Cacholong.
  - Chrysoprase.
  - Plasma.
  - Agate?
  - Heliotrope?
  - Flint.
  - Flinty-Chert.
- *Cellular or Porous Quartz* -
  - Burrh-Stone.
  - Swimming-Quartz.
  - Siliceous-Sinter.
  - Tripoli?

Sp. OPAL. *Silex and Water, with a trace of Alumine.* - - Page 253

Precious-Opal.
§ Hydrophane.
Common-Opal.
Semi-Opal.
Hyalite.
Fiorite, or Pearl-Sinter.
Menilite.

(INDETERMINATE.)

Sp. HORNSTONE? - - 260

Slaty-Hornstone, or Flinty-Slate.
Lydian-Stone, or Black Flinty-Slate.
Iron-Flint.

Sp. JASPER? - - - 263

Common-Jasper.
Egyptian-Jasper.
Striped-Jasper.
Jasper-Opal.
Porcelain-Jasper.

ORDER II. SILICEO-ALUMINOUS.

Sp. FELSPAR (*Common*), *with Potash and Lime.* 266

Adularia Nacry Felspar.
Glassy Felspar.
Labrador Felspar.
Compact Felspar.
Albite?
Soft or disintegrated Felspar.

Sp. JADE? - - - - Page 281
Saussurite?
Nephrite?
Axe-Stone?

Sp. SPODUMENE 278 } *with the new alkali*
Sp. PETALITE - 280 } *Lithia.*

Sp. CHIASTOLITE - - - 290

INDIANITE - - - - 277

Sp. HORNBLENDE, Amphibole, *with Iron, Magnesia, and Lime* - - 292
Basaltic Hornblende.
Actynolite.
Glassy-Actynolite.
Asbestous-Actynolite.

Sp. TREMOLITE, *with Lime* - - 298

Sp. EPIDOTE, *Iron and Lime* - 306
Granular Epidote.

Sp. HYPERSTENE, *Iron, Magnesia, and Lime.*
Anthophylite - - - - 315

Sp. OBSIDIAN - - - 284
Pearl-Stone.

Sp. PITCH-STONE - - 289

Sp. PARANTHINE, *Scapolite, Wernerite* 340

Sp. ELAOLITE, *Fetstein* - - 342

Sp. LEUCITE, *with Potash* - - 332

SODALITE, *with Soda?* - - 334

Sp. MEIONITE - - - 335

Sp. NEPHELINE - - 336

Sp. ZEOLITE, or MESOTYPE, *with Soda and Potash or Lime* - Page 317
Dipyre? *with Lime* 322
Sp. NATROLITE? *with Soda* *ib.*
Sp. LAUMONITE? *with Lime* 331
Sp. STILBITE, *with Lime* 323
Sp. CHABASIE, *with Lime and Soda* - - - 324
Sp. ANALCIME, *with Lime and Soda* - - 325
Sp. HARMOTOME, or CROSS-STONE, *with Barytes* 329
Sp. APOPHYLITE, *Lime and Alkali, Alumine wanting* 330
Sp. PREHNITE, *with Lime* 326

These species are nearly allied; they contain a considerable portion of water in combination, besides the alkalies and lime.

Sp. MICA - - - - - - 343
Lepidolite? - - - - 346
Sp. PINITE - - - - - - 347
Sp. CHLORITE, *with Lime and Iron* - 350
Green-Earth, *with Iron and Potash* - 353
FULLER'S-EARTH - - - 473
LITHOMARGE - - - - 474
CIMOLITE - - - - 475
PORCELAIN-CLAY - - - 476
POTTERS'-CLAY - - - *ib.*
Sp. YENITE. See ORES OF IRON.

ORDER III. SILICEO-CALCAREOUS.

Sp.	GARNET. All the varieties of Garnet contain Iron, which appears to be an essential ingredient. Lime and Alumine are nearly in equal Proportions	Page 357
	Common-Garnet.	
	Precious-Garnet.	
	Pyrope.	
	Cinnamon-Stone.	
	Melanite, or Black-Garnet.	
	Allochroite.	
	Grossular, or Green-Garnet.	
	Aplome.	
Sp.	AXINITE, *with Alumine and Iron*	366
Sp.	VESUVIAN, Idocrase	364
Sp.	AUGITE, Pyroxene, *with Magnesia and Iron*	301
	Sahlite, *with Magnesia.*	
Sp.	LAZULITE, Lapis-Lazuli, *with Alumine*	337
	TABULAR-SPAR	428
Sp.	DIALLAGE. Smaragdite	311
	Bronzite.	

ORDER IV. SILICEO-MAGNESIAN.

Sp.	CHRYSOLITE, or PERIDOT, *with Lime*	368
	Olivine, *with Lime.*	
Sp.	TALC, *with Iron*	348
	STEATITE, *with Iron and Alumine*	471
	Soap-stone, *with Alumine.*	
	Meerschaum.	
	SERPENTINE (indeterminate)	470
	Potstone, *Iron and Alumine.*	
Sp.	ASBESTUS, *with Lime*	354
	Rock-Cork.	356

ORDER V. ALUMINOUS.

ORDER VI. ALUMINO-SILICEOUS.

ORDER VII. ZIRCO-SILICEOUS.

Sp.	ZIRCON, *with Silex*	Page 399
	Zircon-Hyacinth, *with Silex*	402
	Zirconite	*ib.*

ORDER VIII. GLUCO-SILICEOUS.

Sp.	EMERALD. *Glucine, Silex, and Alumine*	403
	Beryl. Ditto.	
Sp.	EUCLASE. Ditto.	408

ORDER IX. YTTRO-SILICEOUS.

Sp.	GADOLINITE	463
	Fluate of Yttria.	
Sp.	YTTRO-TANTALITE	615
	Yttro-Cerite.	

ORDER X. CALCAREOUS.

Sp.	CARBONATE OF LIME. *Lime and Carbonic Acid*	409
Sp.	ARRAGONITE, *contains a little Strontian*	441
Sp.	GYPSUM. *Lime and Sulphuric Acid*	435
Sp.	ANHYDROUS GYPSUM (*without water*)	439
Sp.	FLUOR-SPAR. *Lime and Fluoric Acid*	444
Sp.	APATITE. *Lime and Phosphoric Acid*	447

ORDER XI. CALCAREO-SILICEOUS.

ORDER XII. CALCAREO-MAGNESIAN.

ORDER XIII. MAGNESIAN.

ORDER XIV. BARYTIC.

ORDER XV. STRONTIAN.

APPENDIX.

EARTHY-COMPOUNDS, AND ROCKS.

Sp. 1. QUARTZ.*

1.	Vitreous Quartz	*Quartz-Crystal*, or *Rock-Crystal*
		Amethyst
		Cairngorm
		Yellow-Quartz
		Blue-Quartz
		Red-Quartz
		Avanturine-Quartz
		Granular-Quartz
		Massive Common Quartz
		Rose-Quartz
		Milk-Quartz
		Fat-Quartz
		Cat's-Eye
		Prase
		Fœtid-Quartz.
2.	Flinty or Chalcedonic Quartz	*Chalcedony*
		Carnelian
		Chrysoprase
		Agate
		Heliotrope
		Flint
		Plasma
		Flinty-Chert
3.	Porous or Cellular Quartz	*Burrh-Stone*
		Swimming-Quartz
		Siliceous-Sinter
		Tripoli.

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* The minerals here described as belonging to the species quartz are arranged, for public inspection, in the Cabinet of the British Museum, under the appropriate names of quartzose-substances and chalcedonic-substances. The former comprise all the varieties of vitreous and porous or cellular quartz.

QUARTZ. *Quarz Hyalin.* — No mineral is so abundantly distributed over the surface of the globe as quartz. Entire rocks and strata are sometimes composed of quartz; more frequently it occurs aggregated with other minerals, forming mountains of vast extent and height, and it often fills the veins that intersect the crust of the globe. In many countries, quartz is widely spread over the surface of the land in detached masses, and in rounded pebbles. Grains of quartz form a great part of the sands on the sea-shore, or of extensive deserts. Masses and crystals of quartz occur imbedded in rocks; it also lines the cavities in veins, or of hollow nodules, called *geodes*, and is sometimes found incrusting other minerals. In the vicinity of boiling-springs, it occasionally forms stalactites and spongiform masses; it is also found penetrating the substance of animal or vegetable remains, or filling their cavities either in a compact or a crystalline state.

Quartz is not only the most abundant, but is also one of the purest of simple minerals, consisting almost entirely of siliceous earth, with a slight admixture of water or colouring matter. Notwithstanding the simplicity of its composition, few minerals present themselves in nature under a greater variety of forms; hence the German mineralogists have been induced to class these varieties into several distinct species or sub-species, We cannot, however, adopt such an arrangement; for substances which are essentially the same in composition, and possess the same most important physical properties, we must regard as belonging to one species, though they may present some diversity of colour or form.*

For the convenience of description, all the varieties of quartz may be arranged in three divisions:

1st, VITREOUS QUARTZ, with more or less of a vitreous lustre, occurring crystallized and amorphous.

2d, FLINTY or CHALCEDONIC QUARTZ, with a lustre approaching to waxy, compact, occurring nodular, stalactitical, and amorphous.

3d, POROUS or CELLULAR QUARTZ.

The varieties in the above three divisions when pulverized form a powder which is essentially the same; it is infusible by the blow-pipe,

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* Can a pebble of quartz, and another of flint, be regarded as belonging to different species? They are both essentially the same in composition; for chemical analysis can discover no greater difference between them than between two specimens of quartz from different situations. Flint and quartz possess nearly the same specific gravity and degree of hardness; their other physical properties are also the same, except that flint is always compact, and has less lustre and transparency than many varieties of quartz. If a difference so slight can constitute a species or sub-species, then every variety of lime-stone and marble is equally entitled to rank as a species or sub-species in our systems.

is insoluble in acids, except the fluoric; it feels harsh or meagre to the touch, and scratches the surface of glass or steel when rubbed upon them. These properties are common to every variety of quartz; they all give sparks with steel, when the fragments have sufficient solidity to sustain the shock, and they resist the point of a knife forcibly drawn over them. When two fragments of quartz are rubbed together, they phosphoresce, and emit a peculiar odour. The specific gravity, when crystallized or compact, is very near 2.60, varying a little in different specimens. Such are the essential characters of the species: let us now examine the varieties.

Division 1. CRYSTALLIZED-QUARTZ, when perfectly limpid and transparent, is called *rock-crystal.* When imperfectly transparent or translucent, it is called *quartz-crystal.* The form of the crystals is most commonly an equiangular six-sided prism terminated by a six-sided pyramid, the bottom part of the prism being generally attached to a base; but sometimes the prisms are terminated by similar pyramids at both extremities (Plate III. fig. 33.): another but less common form is a double six-sided pyramid (Plate III. fig. 32.)

Sometimes the solid angles formed by the junction of the prisms with the pyramid appear truncated, forming small rhombic faces, as in fig. 33.; this is the variety called by Haüy *quartz rhombifere*. The sides of the prisms are transversely streaked; but the faces of the pyramids are smooth and splendent. Some of the faces both of the prisms and pyramids are frequently much larger than the rest. When a pin or other small object is viewed through one of the faces of the pyramid, and an opposite face of the prism, the crystal presents the phenomenon of double refraction. Crystals of quartz are sometimes found two feet or more in length, and of considerable breadth, particularly in the island of Madagascar. Sometimes quartz-crystals contain small cavities inclosing air, water, or bitumen, and they not unfrequently inclose crystals of other minerals. Acicular crystals of rutile, resembling brown hair, are inclosed in some of the rock-crystals from Madagascar; and fibrous or acicular crystals of iron-ore occur in many of the rock-crystals that line the hollow balls, called geodes, near Bristol.

Quartz-crystals, or rock-crystals, are found of the largest size, and of the greatest beauty, in the cavities of veins that traverse those rocks denominated primary, such as granite, gneiss, mica-slate, and clay-slate. Rock-crystals occur also in other rocks which are considered as secondary. Beautiful rock-crystals are found on Snowdon in North Wales, a mountain containing organic remains in the schist, near its summit. Rock-crystals are found in Somersetshire, Derbyshire, and various parts of England. There is reason to believe, that they are forming at the present time in the geodes or hollow nodules near Bristol. *

Quartz-crystals rarely exhibit a distinct laminar structure; but the structure may be rendered visible by heating the crystals, and plunging them into cold water. In consequence of the firm adhesion of the laminæ, the crystals most frequently break in a different direction from that of the crystalline structure, and the fracture is conchoidal or undulated.

Crystallized quartz is frequently colourless and transparent or translucent: it occurs also grey, purple, blue, yellow, and of other colours; and hence the crystals have received a great variety of names, and have frequently been confounded with some of the more precious gems.

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* Mr. Johnson, of Bristol, who has formed a magnificent collection of the organic remains and minerals in Somersetshire and Dorsetshire, informed me, that he had, at different times, broken several hundreds of these geodes, and had occasionally found some of the quartz-crystals within them covered with a kind of paste; these were always more brilliant than the rest, and he distinguished them by the appropriate name of living crystals. The formation of quartz-crystals from a kind of siliceous paste has been sometimes observed on the walls of mines.

False crystals of quartz not unfrequently occur, the substance of the quartz having been infiltered into the cavities left by other crystals, or sometimes it is moulded over other crystals, which have afterwards disappeared and left the false crystal hollow. These supposititious or pseudo crystals, as they are sometimes called, are dull and opaque; they have no internal crystalline structure, their edges are not so sharp as those of true crystals.

The following are the principal varieties of coloured crystallized quartz.

AMETHYST, *Quarz Hyalin Amethyste,* is quartz coloured with a slight trace of iron or manganese; the prevailing colour is violet, which is generally unequally diffused through the mass; sometimes the colour inclines to purple-red, brown, or green. Amethyst occurs in veins and cavities of basalt, and in agate balls. The native situation produces a slight difference in the structure and aggregation of amethyst from that of common quartz-crystals. The crystals of amethyst are most frequently double pyramids; it is also found in concretions composed of densely aggregated imperfect prisms, which give to the concretions the appearance of a coarsely fibrous structure; and it sometimes occurs in lamellar concretions. These variations are not greater than what may be observed in almost every species of mineral, when it occurs in different kinds of rock; the surrounding matter having generally a greater or less effect on the form of the secondary crystal, or on the colour or fracture. These variations are too unimportant to constitute distinct species or sub-species. When amethysts are transparent, and the colour bright and equally diffused, they are employed in jewellery, being cut for necklaces and other ornaments. Amethysts are not uncommon in the basaltic rocks of Scotland. The oriental amethyst is the violet sapphire, a gem of much greater value.

SMOKE-QUARTZ, or CAIRNGORM-STONE*, *Quarz Hyalin enfumé*, has a clove-brown colour, more or less intense. Objects seen through it appear as if viewed through a cloud of smoke; when transparent it is much prized in jewellery.

YELLOW-QUARTZ, *Quarz Hyalin Jaune*, or *False-Topaz*. Beautiful specimens are found at Huttenberg, in Carinthia, and in the Brazils. Its inferior specific gravity and inferior hardness may distinguish it from the real topaz.

BLUE-QUARTZ, *Quarz Hyalin Saphirin*, or *False-Sapphire*, is of a pale blue, sometimes inclining to grey; it may be distinguished from the true sapphire by its inferior hardness, and lower degree of specific gravity. It occurs in Spain, Bohemia, and Macedonia. Amorphous blue-quartz is found in Pennsylvania.

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* From Cairngorm, a mountain in Scotland.

Hyacinths of Compostella, are crystals of quartz, of an hyacinth colour, or deep orange-red, derived from oxide of iron; they occur in perfect crystals, which are nearly opaque, near Compostella, in Spain.

Irised Quartz, and **Avanturine Quartz.**— Besides the colours we have enumerated, crystallized quartz has been found green and black; it sometimes presents a play of colours by the reflections from the fissures that traverse it; this is called *irised quartz*, *quarz hyalin irise.* When the fissures are small, or when minute scales of mica are disseminated through quartz, so as to reflect a metallic lustre from numerous points, it is called *avanturine quartz*. Avanturines are sometimes made artificially by heating certain varieties of quartz, and this occasions fissures from which the light is reflected.

Quartz frequently occurs imperfectly crystallized in very irregular groups, and is occasionally found radiated, fibrous, and lamellar. A variety called *hacked quartz* presents incisions, as if cut with a knife, or other sharp instrument, in various directions: these incisions are occasioned by the decomposition of laminæ, or laminar crystals of other minerals, once imbedded in quartz, which have since disappeared.

Granular Quartz, Fr. *Gres*, consists of small imperfect crystals, or grains of quartz, closely adhering without any visible cement. Entire beds and rocks of finely granular quartz form a part of many primitive mountains; this variety of quartz is called by geologists *quartz-rock*. Some of the siliceous sand-stones in the secondary strata are almost entirely composed of granular quartz; they will be described among rocks, after earthy minerals. Elastic quartz will also be described as a variety of sand-stone.

MASSIVE-QUARTZ, or AMORPHOUS VITREOUS-QUARTZ, whether forming entire rocks, or filling the cavities of veins, or in detached masses, or in pebbles, generally presents in some parts indications of a crystalline formation; and the common observer is reminded of a substance bearing some resemblance to glass, and possessing some degree of translucency and of a vitreous lustre. The fracture is either conchoidal or splintery. The most common colours are white and whitish-grey; but it is sometimes brown, red, &c. The principal varieties of massive-quartz are,

ROSE-QUARTZ, which is of a rose-red colour, of various shades, generally rather pale; it is translucent, or nearly semi-transparent; the lustre sometimes inclines to resinous. It has not been found crystallized, but occurs in beds and veins, and in rolled masses. It is found in the island of Col in the Hebrides, and in various parts of the continent of Europe, and also in the province of Maine, in the United States. It is employed in jewellery; but the colour is said to fade by exposure to the light.

Milk-Quartz is similar to rose-quartz in all its other characters except the colour, which is of a milky or blueish white.

Fat-Quartz, or Greasy-Quartz, is of various colours, but the fractured surface appears as if it had been rubbed with oil.

Cat's-Eye, *Quarz Agathe Chatoyant.* — There is reason to believe that various different minerals have been described as cat's-eye. The name is derived from the peculiar play of reflected light which it exhibits, called by the French *chatoyant*, from its resemblance to the reflections observable in the eye of a cat. In some varieties of cat's-eye, this property is entirely derived from the fibrous structure of the mineral; a similar effect may be produced by polishing, in certain directions, all fibrous minerals that are highly translucent, such as fibrous gypsum. Some chatoyant siliceous minerals appear to consist of amianthus penetrated by quartz, a penetration similar to that of wood by quartz. In the British Museum there is an interesting series of specimens of this mineral, in which the amianthus becomes more and more abundant, forming cat's-eye. Other specimens of cat's-eye are composed of fibrous quartz, without any admixture of amianthus. The finest specimens of cat's-eye come from Ceylon; they have commonly a greenish or yellowish-grey colour, and are often somewhat rounded. Cat's-eye is more or less translucent, and the lustre is shining and vitreo-resinous. The fracture is small conchoidal. The specific gravity of cat's-eye varies from 2.60 to 2.64; it is rather harder than quartz. According to Klaproth, it contains — Silex 95, Alumine 1.75, Lime 1.50, Oxide of Iron 0.25.

Cat's-eye is frequently cut with a convex surface, and polished for ring-stones.

PRASE is a leek or olive green variety of quartz, deriving its colour from an intimate intermixture with actynolite. Its colours are dark and dull; it is generally translucent. It sometimes occurs in crystals of the same form as common quartz.

FŒTID-QUARTZ yields the peculiar odour of sulphuretted hydrogen, when struck with a hammer on its angles or edges. This property ceases when it has been exposed to a red heat. In its other properties it agrees with common quartz; it is found near Nantz in France, and in various parts of the United States of America.

DIVISION 2. *Flinty or Chalcedonic Quartz.* — The following are the principal varieties of this division.

CHALCEDONY, *Quarz Agathe Calcedoine,* has a cloudy or milky appearance when held between the eye and the light. This milky nebulosity is sometimes shaded with spots of pale red or blue, or of various other colours. Sometimes the colours are in stripes, or are dendritical. The fracture presents a very compact surface, which is even, or more or less conchoidal, and has a dull waxy lustre. Chalcedony frequently occurs in the cavities of amygdaloid, in nodules, stalactitical and mamillated. Very fine mamillated chalcedony is found in the hollow flints near Sidmouth, in Devonshire. The transition from the flint to chalcedony is almost imperceptible. Chalcedony also occurs in beds and in metallic veins. In some situations it is observed passing into opal; and depositions of chalcedony are sometimes formed over the surface of other minerals, or penetrate the substance of organic remains. Chalcedony, in some rare instances, is covered with cubic chalcedonic crystals. There is a fine specimen of these chalcedonic crystals in the British Museum.

CARNELIAN differs in colour from chalcedony; it occurs in the same situations, and is of various shades of red or yellow, and sometimes intermixed with chalcedony in stripes. The striped carnelians have received the names of sardonyx and onyx. These stones were employed by the ancients for cameos. When a white zone or layer of chalcedony occurs over red carnelian, the red ground gives a beautiful flesh colour to the face cut in chalcedony, and different shades of drapery may be successfully imitated in these stones. An ancient cameo, eleven inches by nine, representing the apotheosis of Augustus, is in the *Bibliothéque Impériale* at Paris; it consists of two brown layers of carnelian, and two of white chalcedony.

Cacholong is a milk-white variety of chalcedony; it [illegible] ~~has a~~ slightly translucent and [illegible] resinous lustre; it is sometimes formed on the surface both of flint and chalcedony, and other siliceous minerals. It was originally found near the banks of the river Cach, in Bucharia, in detached masses, mixed with chalcedony. There is a variety of cacholong which is more nearly allied to opal, and has received the name of milk-opal and opal-cacholong.

Chrysoprase, *Quarz Agathe Crysoprase*, Haüy. — This beautiful mineral may be regarded also as a variety of chalcedony; its common colour is apple-green, of various degrees of intensity; it sometimes occurs grass-green, or olive-green, is more or less translucent, approaching sometimes to semi-transparent. Its other characters agree with chalcedony, except that its hardness is inferior. The only analysis we have of chrysoprase is by Klaproth, who found in it 96.16 parts of silex, with one part of the oxide of nickel, and less than one per cent. of lime, magnesia, alumine, and iron. The nickel is supposed to be the colouring matter. It is to be regretted, that we have no other analysis of this mineral, as Klaproth states its specific gravity at 3.25; whereas the specific gravity, as given by other mineralogists, varies from 2.60 to 2.70. Chrysoprase has hitherto been found only near Kosemitz, in Lower Silesia, in a rock of serpentine. On account of its beautiful green colour, chrysoprase is cut into ring-stones, and is much valued by jewellers; a stone with a pure apple-green colour, nearly transparent, and without lighter spots, is said to be frequently sold for twenty guineas. The colour of chrysoprase, however, is fugitive or changeable, being altered both by moisture and heat, and even by the heat produced in polishing it, when the motion of the wheel is too rapid. It is frequently imitated in paste, but these imitations may be detected by their inferior hardness.

AGATE is principally composed of chalcedony, and occurs like it in nodules of various sizes in basaltic rocks. Agate can scarcely be regarded as a simple mineral, but as an intermixture of several varieties, generally arranged in concentric layers over each other. Sometimes the layers are so arranged as to present the resemblance of fortifications or ruins, and sometimes agates appear to inclose minute arborizations resembling moss; hence they are called *fortification-agate*, *moss-agate*, &c. I am inclined to believe, that some of the layers in agates are composed of more soluble materials than siliceous earth. In a basaltic rock near Berkley in Gloucestershire, which incloses nodules of agate, the nodules in the upper part of the rock are in a state of decomposition; some of the concentric layers have disappeared, leaving the remaining ones like folds of writing-paper, with interstices between each. The minerals that occur in agate are, carnelian, jasper, flint, quartz, opal, and hornstone. Some agates are entirely composed of chalcedony, variously striped.

Heliotrope has generally a dark-green colour, and is frequently marked with red or yellow spots or stripes; it is translucent on the edges, and has a lustre approaching to resinous. It is supposed to be chalcedony coloured by green-earth, and partakes of the same degree of hardness. Heliotrope occurs, like chalcedony, in basaltic amygdaloid. The finest specimens come from Bucharia.

Flint. — This mineral, so common in various parts of England, particularly in the counties containing chalk, and so well known as furnishing gun-flints, is nearly pure silex, tinged with colouring-matter. The mineralogist may regard chalcedony as a variety of flint, possessing greater translucency, and having a rather finer paste. The flints in the beds of green-sand under chalk, frequently pass into chalcedony, and have generally more or less of a chalcedonic appearance. Indeed, could we suppose common flint to be rendered highly translucent, or nearly semi-transparent, it would become chalcedony.

Flint occurs of various colours, black, white, yellow, brown, and grey. It breaks with great ease into sharp-edged fragments; the fracture is conchoidal, the lustre is glimmering, and in some instances shining and resinous; it is always translucent on the edges, and is rather harder than vitreous-quartz. Flint occurs in nodules and in irregular strata, and also forms veins running through chalk, as may be distinctly seen in the chalk-cliffs near Ramsgate. Flint is abundantly distributed over many parts of England, forming pebbles in beds of gravel; it often penetrates the substance, or fills up the cavities of the organic remains of marine animals, particularly of echinites and corallites. The cavity of the echinites in chalk are often entirely filled with flint, the shell remaining calcareous. The cavities of flints frequently contain crystallized vitreous quartz, showing the identity of the two substances; the cavities in the flints from the green-sand are more frequently lined with mamillated chalcedony. In a few instances, we have seen the cavities in the centre of flints filled with calcareous spar.

Plasma appears to be a variety of chalcedonic flint; it has generally a dull-green colour, and is translucent. It has been found at Prussa, near the foot of Mount Olympus. Plasma possesses little beauty, but was used by the ancients as a gem. Its constituent parts, according to Klaproth, are about 97 silex, with a minute portion of alumine and iron. In the analysis there were 2.50 parts loss, probably water.

FLINTY-CHERT, or HORNSTONE. — Flint may sometimes be observed passing into a substance more opaque and earthy, but which is equally hard; this substance, which has received the name of chert, and also of hornstone, may be regarded as an earthy variety of flint. Chert frequently occurs in large masses in the strata of sand under chalk, in the south-western counties of England, the same mass of chert preventing the appearance of perfect chalcedony in one part, and of flint in the other, showing the near connection of all these minerals, which are only different modes of the same substance possessing a finer or coarser paste. In Derbyshire, where strata of chert intersect the mountain lime-stone, the flint appears to have undergone some chemical change during its formation, as it is fusible. This kind of chert may, therefore, be considered as differing from the flinty-chert in the southern counties. It probably contains an admixture of lime.

DIVISION 3. *Cellular and Porous Quartz.*—The minerals in this division have more of an earthy appearance than the preceding varieties of quartz.

Burrh-Stone and Mill-Stone, *Quarz Agathe Meulière*, Haüy, is the most useful of all the varieties of quartz; it occurs in beds and amorphous masses, partly compact, but containing a number of pores or cavities. The fracture is dull and generally earthy, but sometimes smooth, like flint; its colours incline to a reddish-brown or blueish-grey, and the cavities are often filled with ferruginous earth. The cells or pores vary in size, and frequently in different parts of the mass; the larger cavities are sometimes crossed by siliceous threads, or are lined with siliceous incrustations. The principal repository of burrh-stone occurs in the strata over chalk near Paris. It forms beds of nine or ten feet thick, resting on sand-stone, which contains marine organic remains, and is covered by strata containing the remains of fresh-water shells. The more porous parts of the bed are quarried for building-stone; the more compact, forms the substance of all the best mill-stones in Europe. According to Haüy, the larger cavities in the burrh-stone, used for mill-stone, are filled by the workmen with a composition which hardens as it dries. Burrh-stone is found in other parts of the fresh-water strata at a considerable distance from Paris, particularly near Pacy, in the department of Eure; but it has not hitherto been discovered in any other country in Europe. According to Professor Cleaveland, cellular quartz, which he denominates *Burrh-stone*, occurs in Georgia and Northampton county, in the United States.

Swimming-Quartz, *Quarz nectique*, Haüy, is a variety of quartz with an earthy aspect, and so full of pores as to swim for some time on water; it occurs in tubercular masses in clay and incrusting flints near Paris, and is regarded as decomposing flint; it has a spongy appearance, and a whitish or grey colour. According to Vauquelin, it is composed of 98 parts silex. This mineral is sometimes found in the cavities of metallic veins. I have a specimen of swimming-quartz from Redruth in Cornwall.

Porous Siliceous Sinter has a dull earthy appearance, generally a greyish colour. It is formed by depositions from boiling springs, holding silex in solution. This mineral is remarkable as illustrating the power of water to dissolve silex, under the combined effect of compression and a high temperature, in the deep recesses of the earth, and in the vicinity of subterranean fire.

Tripoli. — Some kinds of tripoli, which are composed of siliceous earth, appear to have been formed by siliceous depositions; or, more probably, the earth or iron with which the silex was originally composed has been decomposed and washed away, leaving the siliceous mass light and almost friable.

ESSENTIAL CHARACTERS OF QUARTZ.

Specific Gravity, when not porous, 2.55 to 2.65.
Hardness always sufficient to scratch steel or glass.
Insoluble in all acids except the fluoric.
Infusible by the blow-pipe.

CHARACTERS OF VITREOUS QUARTZ.

Form. — In perfect crystals and crystalline masses, granular, radiated, fibrous, and massive. Primitive form of the crystal (rare), a slightly obtuse rhomboid; angles of incidence of the planes 94° 16′ and 85° 44′. Common forms of the crystals six-sided equiangular prisms, terminated by six-sided pyramids (Plate III. fig. 33.) Incidence of the faces of the pyramid with the adjacent faces of the prism 141° 40′; angle formed by the inclination of the faces of the pyramid at the summit 76° 40′; inclination of the contiguous faces of the same pyramid at their lateral edges, or P on *p*, 133° 48′ (fig. 32.) A double six-sided pyramid (fig. 32.), angles formed by the inclination of the faces at the common base 103° 20′. The faces of the crystals are frequently unequal, but the angles of incidence are invariable.

Structure and Fracture. — Laminar, but seldom visible before the crystal has been heated. Fracture not difficult, surface of the fracture conchoidal, uneven, or splintery.

Affections of Light. — Limpid and of various colours; prevailing colour white or grey; transparent or translucent, refracts doubly. Lustre more or less vitreous, phosphoresces when two pieces are rubbed together.

Distinctive Characters of Quartz. — Crystallized transparent quartz may be distinguished from all the precious gems, which it resembles the most in appearance, by its inferior specific gravity, and its inferior hardness, with the exception of the chrysolite; the latter is scratched by quartz. When perfectly crystallized, the form is sufficient to distinguish quartz from every other species.

Particular distinctive Characters of Flinty or Chalcedonic Quartz. — Lustre inclining to waxy, paste more or less fine, not crystallized or transparent, occurs most frequently in nodules or tubercular masses, stalactitical and mamillated.

Particular distinctive Characters of Cellular and Porous Quartz.—Dull and earthy, containing cavities or pores.

Sp. 2. OPAL.

Precious-Opal.
Common-Opal.
Opal-Cacholong.
Semi-Opal.
Hyalite.
Fiorite.
Menilite.

The minerals belonging to this species occur but in a few situations, and in small masses. They are principally composed of siliceous earth combined with water, to which circumstance the low degree of specific gravity they possess and their inferior hardness may be partly owing; they are all infusible. Opaline minerals have probably been formed by depositions from water holding silex in solution; they bear some resemblance to chalcedony, but the minute portion of water, which may perhaps be regarded as an accidental ingredient in the latter mineral, is an essential constituent part of opal, often forming one-tenth of its whole weight.

The most perfect opal is sometimes called *noble* or *precious opal.*

PRECIOUS-OPAL is of a blueish or milk-white colour, but when held between the eye and the light appears a pale orange or yellow. It is highly translucent, approaching to semi-transparent; its internal lustre when broken is splendent and vitreous, and the fracture is conchoidal. But the opal is particularly characterised by the various beautiful and changing colours which it exhibits by reflected light, which are thus correctly and eloquently described by Buffon. "Of all chatoyant minerals, the opal is the most beautiful, though it has neither the hardness nor the splendour of true precious gems; but the light which penetrates it, enlivens it with the most pleasing colours, and seems to move on in undulating reflections, so that the eye is less dazzled than fascinated by the soft effects of its beauty." Pliny dwells with peculiar satisfaction on the colours of the opal. "It possesses," he says, "the fire of the carbuncle, the purple of the amethyst, and the brilliant green of the emerald, sometimes shining together, sometimes single, and sometimes delightfully blended with each other. Nor is this all, blue and orange are often added to the above, and they all receive a charming freshness from the white and splendent ground in which the colours play, and appear to flow out only to return again, and prolong the pleasing effect."

Some naturalists ascribe the play of colour to reflections from minute fissures, which are supposed to traverse the opal. The irridescence in the noble opal appears to be produced by this cause; but the opalescence is certainly produced by a different cause, and may be successfully imitated by mixing the oxide of tin with glass, or soap with alcohol, or by the diffusion of very minute translucent particles, through almost any transparent medium. In the opal, the internal reflection which occasions the opalescence, probably proceeds from numerous minute pores, that also diminish the specific gravity, and occasion the absorbent property so remarkable in some varieties of this mineral, which are well known to absorb moisture and adhere to the tongue.

The hydrophane, a variety of opal, possesses this property in a high degree; it is nearly opaque, but becomes transparent, and acquires a splendid lustre when immersed in water. Precious opal is softer than felspar; its specific gravity varies from 2.07 to 2.11.

COMMON-OPAL differs from precious opal, by possessing a less effulgent and various play of colours. The colours are, white, red, yellow, or green; but they do not occur together: it has less translucency than precious opal, and has a smaller portion of water in its composition. Its other characters are nearly the same as those of the precious opal.

Precious and common opal never occur crystallized, but are found massive or in veins, and sometimes disseminated. Their principal repository is in porphyritic or basaltic rocks, which are generally more or less decomposed, and are supposed to have had a volcanic origin. The only known opal-mine is that of Czerwenitza, in Hungary. According to the account of Dr. Townson, it is situated in a hill, composed of terras and decomposed porphyry, and is found at the depth of about eighteen feet. They extract the stone which serves as a matrix and separate the opals; many of them are decomposed, and some have the properties of the hydrophane. Precious opal occurs chiefly in porphyry and amygdaloid; common and semi opal occur in metallic veins, and have been occasionally found in some of the mines of Cornwall.

MILK-OPAL, or OPAL-CACHOLONG, is translucent and milk-white.

SEMI-OPAL is nearly opaque; it has no play of colour; the lustre is generally faint. The common colours are white or grey; but it is sometimes brown or greenish-grey, approaching to green. It is softer than felspar; the specific gravity varies from 2.0 to 2.18. Semi-opal occurs in volcanic and basaltic rocks, and also in metallic veins. It sometimes penetrates the substance of wood, and of fossil teeth.* The constituent parts of semi-opal, as given by Klaproth, are — Silex 85, Alumine 3, Ammoniacal Water 8, Carbon 5, Oxide of Iron 1.75, Bituminous Oil 0.33.

Semi-opal seems nearly allied to cacholong and white flint; but is distinguished from them by its inferior degree of hardness and specific gravity.

Hyalite. — This mineral is nearly allied to opal, both in chemical composition, physical properties, and the similarity of the rocks in which it occurs; but it is destitute of opalescence. Hyalite bears a striking resemblance to gum-arabic in appearance; it has a pale yellowish colour, a vitreous lustre, and is nearly semi-transparent; the surface is smooth, mamillated, and shining; it occurs lining the cavities of basaltic amygdaloid near Frankfort on the Maine, and in volcanic countries. Its constituent parts are, Silex 92, Water 6.33.

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* Petrified wood is sometimes found penetrated by semi-opal, and has received the name of wood-opal.

Fiorite, or Pearl Sinter, appears to be similar in its nature to hyalite, but is nearly opaque. It has a white or pearly-grey colour, and a pearly lustre; it occurs stalactitical, and in botryoidal concretions, composed of thin concentric laminæ. It is deposited from the water of boiling springs, or in the vicinity of volcanic fire.

Menilite.—This mineral, which hitherto has been found only at Menil Montant near Paris, occurs in nodular or tuberose masses, in a species of schist, which has received the name of adhesive slate. Menilite is nearly allied to opal in composition, consisting, according to Klaproth, of 85.5 Silex, 11 Water and Carbonaceous Matter, 1 Alumine, 0.5 Oxide of Iron. Its specific gravity, like that of opal, is about 2.18. The grey menilite is somewhat heavier, being about 2.27. The hardness of menilite is nearly the same as that of flint, which it resembles, but inclines to the state of semi-opal. It has a grey or liver-brown colour externally; the surface is sometimes blueish, smooth, and mamillated; the lustre internally is faintly resinous; it is translucent on the edges. Menilite has sometimes a lamellar or slaty structure, like that of the adhesive slate in which it is imbedded; a substance agreeing nearly in composition with menilite; but it is soft and highly absorbent, adhering to the tongue, from which it derives its name.

Opaline minerals are not abundant in nature. The precious and common opal are prized as articles of jewellery, and were, as we learn from Pliny, held in high estimation by the ancients. He informs us, that the celebrated opal which Nonius, the Roman Senator, refused to give Mark Antony, (a refusal which occasioned the banishment of its possessor,) was in existence when he wrote. Its size was equal to that of a large walnut, and it was valued at an immense sum.* Dr. Bright informs us, that the celebrated opal in the Imperial Museum at Vienna, weighs eighteen ounces. (Travels in Hungary.) Small portions of brilliant opal sometimes occur in porphyry which is polished; it is used for snuff-boxes and ornaments, and the brilliant specks of opal produce a very pleasing effect.

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* Considering the imperishable nature of the precious gems, the high estimation in which they are held, and the avidity with which they have been sought, ever since the commencement of civilization in Asia and Europe, we might naturally suppose that their quantity was constantly increasing. —But where are all the most rare gems particularly described by ancient writers? and what has become of the vast number of precious stones brought during several thousand years from their native repositories? The answer must be sought in the folly and ignorance of mankind, and in the wickedness and rapacity of their oppressors. Doubtless the most valuable gems were often concealed, to preserve them from public and private plunderers, and were ultimately lost when their possessors perished. The splendid Diamonds worn in the breast-plate of Tippoo Saib on the day when he was slain, have not been seen since; it is supposed, that they were secreted by a private soldier, to prevent their becoming a part of the general plunder belonging to the *Christian army.*

The mineralogical characters of the species may be given as distinctive or negative, rather than positive.

Specific Gravity rarely exceeding 2.2.

Hardness inferior to felspar (except menilite and opal-cacholong.

Form. — Never crystallized. Most frequently in nodules or tuberose masses.

Affections of Light. — Semi-transparent or translucent, more or less opalescent (except menilite). Lustre and colour various; infusible and insoluble in all acids except the fluoric.

Sp. 3. HORNSTONE.

Common Hornstone.	*Iron Flint.*
Flinty Slate.	*Lydian Stone.*

The name Hornstone has been given to a variety of minerals, nor do mineralogists yet agree in the precise meaning of the terms, Pierre de Corne, Petro-Silex, and Paliopetre, of the French naturalists, which are supposed to designate this substance. It may, however, be stated, that a mineral sometimes occurring in veins, in other instances in beds, and which bears a close resemblance to flint, but has more of an earthy aspect, has generally received the name of hornstone. Some mineralogists have divided hornstone into three sub-species, splintery hornstone, conchoidal hornstone, and wood-stone: but the various minerals called hornstone, differ in one essential character, some being fusible, and others infusible; and this character is of far greater importance than the mode of fracture. Let us then class such flinty minerals as are infusible with hornstone; and those which resemble them, but are fusible, with compact felspar, a mineral often confounded with hornstone. Minerals which, like hornstone, never occur crystallized, and which sometimes form entire beds of rock, may, perhaps, be more properly called earthy compounds than simple mineral species, as the silex of which they are principally composed appears capable of forming various admixtures with other earths or alkalies; and when the lime or alkali exists in any notable proportion, they pass by insensible gradation into compact felspar, and are fusible. Infusible hornstone forms the bases of many porphyritic rocks.

Common Hornstone.—The prevailing colours are grey of various tints; sometimes greenish or yellowish; it is also red. It is more or less translucent, has a conchoidal or splintery fracture; its lustre is dull or glimmering; it is harder than felspar. Hornstone sometimes occurs in the form of supposititious or false crystals. Hornstone has not been analysed, but from its near resemblance to flint, is generally arranged with siliceous minerals.

Flinty-Slate, Hornstone-Slate, or Indurated Slate, contains a larger portion of siliceous earth than argillaceous schist, (clay-slate, Werner,) from which it derives a greater degree of hardness: in some instances, it appears approaching to the state of flint. Its prevailing colour is grey; sometimes it is striped; the lustre is dull; it is generally translucent at the edges. Flinty-slate varies in hardness; some varieties are nearly as hard as quartz; it forms beds of vast size and thickness in many alpine districts, and is traversed by veins of quartz; but they are rarely, if ever, metalliferous. Flinty-slate occurs in Cumberland, and in Charnwood Forest, in Leicestershire.

Lydian-Stone differs from common flinty-slate, having a black or greyish-black colour, but is often traversed by minute veins of white quartz; it forms beds in flinty-slate. Considerable masses of black flinty-slate occur on the banks of Lowes Water, but I have never seen this mineral in *situ*, in the vicinity of these Lakes. On account of its hardness and colour it was much used formerly as a touch-stone, to try the purity of gold or silver by the colour of the streak left, when the metals were drawn across its surface.

Iron-Flint differs from hornstone, in having a large portion of iron intermixed or combined. Its principal colours are brownish-red. It occurs in iron-stone veins and in ferruginous sand-stone.

It is found in roundish pebbles, in some of the midland counties, particularly near Ashby-de-la-Zouch, in Leicestershire. These pebbles are used in burnishing the gilding on China. According to the analysis of Bucholz, some varieties of iron-flint contain near 76 Silex, and 22 of red Oxide of Iron; it is opaque, and has a conchoidal fracture, with an internal resinous lustre. Some mineralogists class with iron-flint red crystallized quartz; but this contains but a comparatively small portion of iron, and differs in its other characters from iron-flint.

SP. 4. JASPER?

Common Jasper.	*Jasper Opal.*
Striped Jasper.	*Porcelain Jasper.*
Egyptian Jasper.	

Jasper being one of those minerals that never occur crystallized, the proportions of its constituent parts are not ascertained, and are probably variable. Jasper is composed of silex, alumine, and iron. It is opaque, and generally dull; the colours are various, of which red, brown, and yellowish-brown, passing into yellow and sometimes green, are the most common. The colours are sometimes striped. The specific gravity and degrees of hardness vary in the different varieties. From the quantity of iron which enters into the composition of the dark-coloured jaspers, they are conductors of electricity. Jasper is nearly as compact in its paste as flint, and the fracture is conchoidal or even.

COMMON JASPER, *Jaspe commune*, occurs in veins, and in large nodules in amygdaloid, and also in large irregular-shaped masses or entire beds in primitive mountains. Its prevailing colours are, red, brown, and yellow, of different shades, and sometimes intermixed or spotted; it is opaque and generally dull; the fracture is conchoidal or even. The colour of jasper may sometimes be derived from manganese, as I have observed beautiful red jasper in some of the beds of manganese near Dodscombe Leigh, in Devonshire. Common jasper receives a high polish, and is sometimes used for vases, &c.

STRIPED-JASPER, or RIBBON-JASPER, differs from common jasper in the arrangement of its colours, which are striped or clouded, or in concentric curves. It occurs in claystone-porphyry, at the Portland hills near Edinburgh. The green striped-jasper is found in the district of Orenburgh in Siberia. The fortress of Orskaia is built on a rock of this jasper.

EGYPTIAN JASPER. — This variety of jaspar is called red or brown Egyptian jasper, according to the colour; it is found in loose rounded masses on the sandy desarts of Egypt, particularly near Suez. These rounded masses of jasper also occur in extensive beds of breccia or amygdaloid, which decompose, and the nodules fall out, and are spread over the country. The colours are, red, brown, and yellow, and are singularly arranged in curved and contorted stripes. This jasper takes a high polish, and is cut into snuff-boxes and ornaments.

Jasper-Opal. — A variety of jasper which has internally a shining vitreous or resinous lustre, and which has a low degree of specific gravity, not exceeding 2.08, has received the name of jasper-opal. It occurs in porphyry in Hungary, Siberia, and Saxony. Its constituent parts, as given by Klaproth, are — Silex 43.5, Oxide of Iron 47, Water 7.5. It is more easily frangible than the other varieties of jasper. It ought, perhaps, to be classed with pitch-stone, to which it bears a great resemblance.

Porcelain Jasper presents various shades of blueish-grey, blue, red, and yellow. These colours are often clouded or in spots. It occurs massive, and is cracked in various directions. Internally it has a glistening vitreo-resinous lustre. The fracture is smooth and imperfectly conchoidal. This substance often resembles externally a semi-vitrified brick.

Distinctive Characters of Jasper. — Jasper is distinguished from hornstone, compact felspar, flint, and carnelian, by its nearly perfect opacity. Its specific gravity extends from 2.3 to 2.6. Egyptian jasper, brown jasper, and jasper-opal, are rather harder than quartz; the other varieties are scratched by quartz. Jasper never exhibits a lamellar or crystalline structure, but is always compact. All the varieties, except porcelain jasper, are infusible.

Jasper, according to Patrin, forms entire mountains of vast extent in some parts of Siberia. In many instances, jasper appears to have derived its origin from beds of clay which have been indurated or semi-vitrified by volcanic fire. This mode of its formation is illustrated by porcelain jasper, which is evidently formed by fire, as it is found in the vicinity of coal-beds that have burned for many years, whereby masses of clay or shale have become semi-vitrified. This jasper frequently contains impressions of vegetables, similar to those found in coal-shale.

Sp. 5. FELSPAR.

1. *Common-Felspar.*
   Albite.
2. *Adularia, or Moonstone.*
   Sun-Stone.
   Glassy Felspar.
3. *Green Felspar, or Amazon-Stone.*
4. *Blue Felspar?*
5. *Compact Felspar.*
6. *Soft, or disintegrated Felspar.*
7. *Indianite?*

Felspar * is one of the most abundant of simple minerals; it forms a considerable part of many

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* Felspar signifies originally mountain-spar; the word *fel*, denoting a mountain, is still used in some of the northern counties of England, as the mountains Cross Fell, Bow Fell, Sca Fell, &c.

rocks and entire mountains in almost every alpine district; it is also a principal component ingredient in many basaltic and volcanic rocks, and frequently occurs filling veins, and also in detached crystals, imbedded in porphyritic rocks.

Almost all the varieties of felspar have a distinctly laminar structure, cleaving with polished surfaces in two directions, at right angles to each other. There is also another oblique cleavage, which is more indistinct, and the surface produced by it is generally dull. The specific gravity is about 2.60. Most of the varieties are inferior in hardness to quartz, but yield with difficulty to the point of a steel knife; they are all fusible before the blow-pipe, into a white frit or enamel. The primitive form is an oblique-angled parallelopiped (Plate III. fig. 34.) The distinct rectangular cleavages are parallel to the faces P and M.

Common Felspar. — The prevailing colours incline to white or red, of various tints; it is sometimes grey or greenish; it is more or less translucent. The lustre is vitreous, inclining to pearly, and is shining, and in some varieties splendent. Common felspar, whether in masses or in crystals, has always a laminar structure. When perfectly crystallized, the most common forms of the crystals are an oblique four-sided prism (Plate III. fig. 35.) *Felspath Unitaire*, Haüy. —A six-sided prism, truncated on four of the edges, forming six large and four small planes, terminated by dihedral summits at each extremity (fig. 36.) This variety is called by Haüy *Felspath quadrecimal.* — A six-sided prism, terminated by irregular five-sided summits, (fig. 37.) *Felspath sexdecimal.* — A broad equiangular six-sided prism, terminated at each end by two planes, (Plate III. fig. 2.) *Felspath Bibinaire.* — Sometimes the primitive form (fig. 34.) is slightly altered by truncation. — Haüy has described not less than twenty secondary forms of crystals of felspar; for the convenience of description, they may be referred to four-sided or six-sided prisms, variously truncated and bevelled. Some varieties of felspar are curvedly lamellar.

Common felspar forms the largest component part of granitic rocks, whether of granite, sienite, or green-stone. It forms the base of many porphyries, and occurs in imbedded crystals, in almost every variety of porphyry. According to the observations of Cordier, it is a component part of most volcanic rocks.* When associated with hornblende in green-stone, it is often coloured by the hornblende, but is sometimes white. Common felspar frequently fills veins in primitive

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* According to the same mineralogist, those lavas in which felspar exists in the proportion of 70 to 90 per cent. have a colour inclining to white or grey; and those in which augit forms the prevailing ingredient, are dark grey, approaching to dark brown or black.

mountains, and is also found in isolated masses of considerable size, in granite and gneiss, and it frequently forms entire beds, alternating with these rocks.

Immense veins of felspar, mixed with a little quartz and mica, traverse granite in the vicinity of Aberdeen.

It is unnecessary to state the localities of common felspar, as it is found in all granitic countries. Cornwall, Devonshire, and the Malvern Hills in Worcestershire, may be mentioned as situations where felspar is abundant. Very splendent and large crystals of dark-red felspar, occur in the porphyritic granite near Shap, in Westmoreland.

ALBITE is a variety of common felspar, recently found at Brodbo; it has a promiscuously broad fibrous structure. The colour is a greyish-white, and the lustre glistening or shining; it is translucent. The constituent parts are given with those of felspar.

ADULARIA, *Felspath nacré*, may be regarded as the purest variety of felspar. The prevailing colour is greenish or greyish-white; it has a splendent lustre inclining to pearly; it is highly translucent or semi-transparent. Adularia is the hardest variety of felspar; it scratches quartz feebly. It occurs both massive and crystallized, in veins that traverse granite; it has been found in Bamffshire and the Isle of Arran. In the former, it occurs with mica, quartz, and garnets or cinnamon-stone. The most beautiful adularia in Europe is brought from the vicinity of St. Gothard; but the finest specimens employed by the jewellers, come in rolled pieces from the Island of Ceylon. According to Professor Cleaveland, it occurs in various parts of the United States.

On account of the beautiful chatoyant reflections of pearly light which some varieties of adularia present, when cut in a rounded form and polished, they have been called moon-stones by jewellers, and are much valued. These chatoyant reflections, depend on the translucency and laminar structure of adularia, and the peculiar direction in which the laminæ are intersected in cutting and polishing the stone.

There is one variety of felspar extremely rare, allied to adularia, but reflecting a golden light; it is distinguished by the French jewellers as *Sun-stone, Pierre de Soleil.* This scarce variety is found in the Island of Cedlavatoï, near Arch-angel. It is sometimes called *oriental avanturine.*

Glassy Felspar always occurs imbedded in trap or pitch-stone, in broad rectangular crystals, or amygdaloidal pieces, with a laminar structure; its colours are greyish or yellowish-white; it is transparent, and has a splendent vitreous lustre. It is softer than common felspar, yielding to the knife.

Amazon-Stone, or Green Felspar, is a va iey of felspar which has a bright green colour, varying internally; the lustre is silky, and sometimes spotted with silver-white points. It comes from Greenland and Russia. There is a very large specimen of an emerald-green colour in the British Museum, from Cathareniburg, in Siberia.

Blue Felspar is considered by some mineralogists as belonging to a distinct species from felspar; it is only found in Styria. Its colours are a whitish-blue, the lustre glistening or shining; the laminar structure is less distinct than in many of the varieties of felspar. It contains, according to Klaproth, Silex 14, Alumine 71, Lime 3, Potash 0.35, Oxide of Iron 0.75, Water 5. The alumine is in greater proportion in blue felspar, than in common felspar; its specific gravity is also greater, being 3.00. Its hardness is the same as common felspar.

Labrador, or Opalescent Felspar, is distinguished by the rich and varied play of colours which it exhibits, which are, blue, yellow, green, red, and brown; but these colours are only seen when viewed in certain positions; in other positions its colour is generally a darkish-grey. The vivid colours are confined to certain parts of the surface; their lustre is splendent, and frequently approaches to metallic. Labrador felspar has the laminar structure and other properties of common felspar. It is found in rolled masses of sienite on the coast of Labrador. The same mineral is found near Laurwig, in Norway. It occurs as a constituent part of zircon-sienite; the colours are principally blue. There are fine specimens both of the blue and red from Laurwig, in the British Museum. The brilliant colours in Labrador felspar appear to be caused by a slight separation of the translucent laminæ, producing a certain refraction and dispersion of the reflected rays. The Count de Bournon describes a specimen of Labrador felspar in his collection, which, when placed in a certain direction, displayed beneath the polished surface an immense number of brilliant minute laminæ (*paillettes*) ranged symmetrically, like the microscopic feathers on the wings of a butterfly, which they very much resembled.*

Compact Felspar. — Under this variety, some mineralogists place common felspar, when it is indistinctly laminar; and inform us, that compact felspar is sometimes crystallized. The term compact ought, I conceive, to be restricted to those varieties where the laminar structure is not discernible, and which have a splintery or conchoidal fracture, breaking into sharp-edged fragments. Compact felspar bears the same relation to crystal-

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* The surface of glass, when cut in parallel lines, not more than the three-thousandth part of an inch distant from each other, reflect a beautiful play of various colours.

line felspar, as flint to quartz. Common felspar may be observed passing through all the different states, from the perfectly crystalline to the compact. In the latter state, it forms the paste or base of many porphyries, and is intermixed with hornblende in greenstone. It also constitutes rocks which are nearly homogeneous; but they often contain small grains of quartz or chlorite. Compact felspar is more or less translucent; its prevailing colours are whitish-grey and red. It has a glimmering lustre; the specific gravity is nearly the same as common felspar; its hardness is sometimes greater than that of crystalline felspar. Compact felspar is fusible before the blowpipe, and this character serves to distinguish it from hornstone, with which it is often confounded.

Soft or Disintegrated Felspar.—A mineral substance which is sometimes lamellar, and sometimes in crystals, but more frequently compact and massive, and which is much softer than felspar, occurs in some granite countries, as in Cornwall; and is supposed by many mineralogists to be felspar in a decomposing state, as the crystals agree in form with those of felspar. It is not improbable, that in many instances its soft state is not the result of decomposition, but that the firm adhesion of the molecules has been prevented by some unknown cause.*

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* It is probably the same cause which has prevented various beds of clay from forming solid stone.

Soft felspar is much used in the manufacture of china and fine earthen-ware, and is obtained from Cornwall. It is in fact a white granite, in which soft felspar abounds ; it contains a small portion of quartz and some mica. Under the term of decomposed felspar, may be also placed all the varieties of this mineral from those which are softened or tarnished externally, to porcelain earth, which appears like a white clay. These varieties are infusible, owing, as is supposed, to the loss of the potash, which is a component part of hard felspar.

ANALYSIS OF THE VARIETIES OF FELSPAR.

	Adularia.	Glassy Fels.	Com. Fels.		Amazon Stone.	Albite.
Silex	64	68	60.25	66.75	62.83	79
Alumine	20	15	22	17.50	17	18.25
Lime	2	——	0.75	1.25	3	11.75
Potash	14	14.5	14	12.00	16	soda
Iron	—	0.5	——	0.75	—	——
	Vauquelin.	Klaproth.	Rose.	Bucholz.	Vauquelin.	Eggertz.

	Lamellar Soft Felspar.	Earthy Felspar.
Silex	74	71.15
Alumine	14.5	15.06
Lime	5.5	1.92
Water	——	6.73
Loss	6	4.37
		Vauquelin.

The uses of felspar as a simple mineral are not very numerous. Adularia, Labrador felspar, and green felspar, are polished for ornaments, and the various kinds of decomposed felspar, are largely employed in the manufacture of porcelain and earthen-ware. Felspar, as a principal component part of porphyry and granite, furnishes the most durable materials for architecture.

ESSENTIAL CHARACTERS OF FELSPAR WHEN UNDECOMPOSED.

Specific Gravity, from 2.56 to 2.66.

Hardness, when sound, considerably greater than window-glass.

Fusible, without addition, by the blow-pipe.

CHARACTERS OF CRYSTALLINE FELSPAR.

Form. — In crystals and crystalline masses. — Primitive form an oblique-angled parallelopiped (Plate III. fig. 34.) The angle of incidence of the faces M and P is 90°, of the faces M and T 120°, and the acute angle formed by the incidence of P upon T $68\frac{1}{2}°$. The principal secondary forms are oblique four-sided prisms, variously terminated and truncated. (Plate III. figs. 2. 85, 86, 87.) Sometimes the secondary crystals are rhomboidal.

Structure. — Distinctively lamellar; cleaves easily in two directions (M and P, fig. 34.) at right angles to each other, presenting smooth shining faces; it cleaves in a third direction with a dull surface; this third cleavage not easily obtained.

Affections of Light. — Colours various; prevailing colours red and white; more or less translucent; some varieties transparent; lustre vitreous, and inclining to pearly, and splendent or shining, in the surface formed by the principal cleavage.

DISTINCTIVE CHARACTERS OF COMPACT FELSPAR.

No visible laminar structure; fracture splintery.

OBSERVATIONS ON FELSPAR.

The frequent occurrence of this mineral in rocks, considered by geologists as belonging to very different formations, appears to result from the great tendency of silex to unite with a definite portion of alumine. If we take adularia as a type of felspar in its purest form, the proportion in which these earths combine are nearly as three parts of silex to one of alumine.* How far the potash in felspar is an essential ingredient, or how far it may be supplied by a greater portion of lime, without changing the crystal-

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* If we calculate the proportionate weight of a particle of silex and alumine after Berzelius, the proportion of 3 to 1 will be more accurate.

line structure and constituting a new species, remains to be determined.

Beside the definite proportion of silex, alumine, lime, or potash, which chemically combine in felspar, a portion of the prevailing ingredient in the mass or solution, from which the felspar was crystallized, may possibly become mechanically intermixed without changing the crystalline form; as we know this to be sometimes the case with substances foreign to the composition of a crystal. Hence, a perfect agreement in two analyses of the same species of mineral is seldom obtained.

It is probable also, that the newly-discovered alkali, *lithia*, may be found combined in several varieties of felspar. Blue felspar ought, perhaps, to be classed with andalusite, and future discoveries may lead us to class with felspar, indianite, petalite, spodumene, and many other minerals now considered as distinct species.

INDIANITE? was first described and named by the Count de Bournon; it comes from the Carnatic, and forms the substance of a rock, in which crystals and masses of corundum are imbedded; it is frequently intermixed with hornblende and other minerals. Indianite is brought to this country in amorphous greyish-white masses, which have a granular structure, resembling that of coarse-grained sand-stone; the finer-grained varieties nearly resemble in colour, structure, and translucency, granular primary lime-stone, or white marble. The separate grains which compose the masses of indianite have each a laminar structure. The specific gravity is 2.74. The hardness is less than that of felspar; it scratches window-glass; it is infusible before the blow-pipe, but is softened by acids. The constituent parts of indianite, according to Chenevix, are — Silex 42.5, Alumine 37.5, Lime 15, Iron 3.

Indianite differs from felspar in its composition, by the exchange of lime for potash. As it has never been found crystallized, we cannot determine whether this difference ought to place it as a distinct species; probably it should be classed as a granular variety of felspar.

Sp. 6. SPODUMENE, or TRIPHANE.*

This mineral bears a striking resemblance to felspar, but may be distinguished from it by well-

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* Spodumene from the Greek *spodos*, ashes, as it was said to form ashes before the blow-pipe. — Triphane from the Greek, implying — *apparent in three directions*.

marked characters. Its specific gravity is greater, being about 3.20. It occurs in masses and disseminated, and has three distinct cleavages, two in the direction of a rhomboidal prism, with angles of 80° and 100°, and a third parallel to the smaller diagonal of the prism: hence it may be split either into four-sided or three-sided prisms, which have shining lateral surfaces and a pearly lustre. The fracture across the prism is uneven and small grained. Spodumene is translucent; the prevailing colours incline to greenish-white or grey. Before the blowpipe, it presents the remarkable appearance of dividing into yellow scales, and afterwards melting into a greenish-white glass. Spodumene is further distinguished by containing about 8 parts of the newly-discovered alkali lithia, combined with 64 parts of Silex, 24 of Alumine, and about 2 of Iron. This mineral was first found in the Island of Utoê in Sudermanland, in Sweden, and has recently been discovered in a granitic rock in the Tyrol; and more recently at Killiney, near Dublin. *

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* I am informed by Mr. Heuland, that the mineral called Killinite, from the same place, is a variety of spodumene.

SP. 7. PETALITE.

Petalite nearly resembles some varieties of quartz; its colour is white with a slight tinge of purple, when triturated the powder is snow-white. The hardness of petalite is about equal to that of felspar, to which mineral and to spodumene it seems nearly allied. Petalite has a lamellar or coarsely fibrous structure, with a two-fold cleavage, parallel to the sides of a rhomboidal prism, with angles of 100° and 80°; two of the planes are splendent, and two are dull. Some varieties of petalite are compact. Before the blow-pipe, by continued heat it becomes covered with a glazed surface, which, on examination with a lens, appears full of minute bubbles. It loses its colour in highly concentrated nitric acid, and is partially soluble. The acid at the same time becomes clouded. The prussiated alkali throws down a green precipitate, and the solution became first blue and then brown. Petalite is remarkable, as being the first mineral in which the recently-discovered alkali, called lithia, was discovered. The constituent parts are—Silex 80, Alumine 15, Magnesia 3, Lithia 2. Its specific gravity is stated by Dr. Clarke at 2.45. The two lateral cleavages of petalite are the same as those of spodumene, with which it further agrees by containing lithia.

Sp. 8. JADE?

Saussurite. | *Axe-stone.*
Nephrite.

The minerals which are generally classed with jade, and are supposed by some mineralogists to be varieties of felspar, are saussurite, nephrite, and axe-stone, or beildstein; they agree in possessing a considerable degree of tenacity; they have a greasy lustre, and generally feel more or less unctuous to the touch; their prevailing colours are light-green or greenish or yellowish white; they are translucent, massive, and compact. The geological position of axe-stone, the oriental nephrite, or jade, is unknown. It is suspected with much probability by the Count de Bournon, that the ornaments brought from India, said to be jade, are often made of compact felspar, or of prehnite, and sometimes of compact asbestus; and he is inclined to doubt whether there be any substance to which the term jade can properly be applied as a designating species (*Catalogue Minéralogique*, p. 66.)

Saussurite, *Jade tenace*, *Felspath tenace*, and *Jade de Saussure.*—Its prevailing colours are green and greenish or yellowish-white or grey; it is faintly translucent. Saussurite is extremely tough; the fracture is splintery and compact, and the fragments sharp-edged. According to Professor Jameson, it sometimes presents an imperfect laminar structure, with a double rectangular cleavage. The specific gravity is from 3.20 to 3.34. Some of the varieties of saussurite are harder than quartz, but others yield to the knife*; before the blow-pipe it melts with difficulty on the edges or angles. The constituent parts, as given by Klaproth, are—Silex 49, Alumine 24, Lime 10.50, Magnesia 3.75, Soda 5.50, Iron 6.50. This mineral was first particularly described by Saussure, and was called saussurite by his son. It occurs in various parts of Switzerland, and is often intermixed with diallage, and is found in rolled masses in the valleys. It occurs also in different parts of the continent of Europe. A mineral nearly resembling saussurite, but softer, is intermixed with *diallage metalloide* near the Lizard in Cornwall. Its colour is whitish-green, and the structure is imperfectly lamellar. A similar mineral, but nearly pure white, or faintly tinged with green, occurs at Glentilt in Perthshire; it scratches felspar, and feebly scratches quartz; both these show the transition from common felspar to saussurite.

NEPHRITE, *Jade nephriteque*, Haüy.—This mineral, which derives its name from its supposed virtues in curing nephritic complaints, being cut

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* This is the case with a specimen sent me from Switzerland, intermixed with apple-green diallage.

into plates, and worn as an amulet attached to the neck. It was originally brought from Persia, and is manufactured in the East into the handles of sabres and knifes. The prevailing colours are leek-green and greenish-white; it is strongly translucent, and has an oily lustre, and an unctuous feel. The specific gravity of nephrite varies from 2.97 to 3.02. It is seldom so hard as quartz; before the blow-pipe it melts into a white enamel. The constituent parts, as given by Saussure, are—Silex 53.75, Lime 12.75, Alumine 1.5, Oxide of Iron 5, Oxide of Manganese 2, Soda 10.75, Potash 8.5, Water 2.25. The Mexican jade, analysed by Karsten, gave the following constituent parts: — Silex 50.50, Magnesia 31, Alumine 10, Iron 5.50, Chrome 0.05, Water 2.75. The known localities of jade in Europe are, Switzerland, where it occurs in granite and gneiss; in the Hartz it occurs in veins traversing greenstone. It is found in Mexico, and in Pennsylvania and Rhode Island in the United States.

Axe-stone, *Beildstein*, Werner, *Jade-axien.* — The prevailing colour is oil-green or greenish-grey; the structure of large specimens is slaty, and the cross fracture splintery; it is compact and massive. Axe-stone is neither so hard nor so translucent as nephrite, and melts with greater difficulty. It is found in some of the South Sea islands, and is used by the natives for hatchets and ear pendants, and receive a tolerably good polish. The mineral called by Werner *beildstein*, which comes from China, is stated by Bournon to be a compact prehnite. This stone, called by the Chinese *Yu*, is arranged with prehnite in the British Museum, and some of the specimens seem to show a direct transition into prehnite; but according to the description of it recently given by Mr. Clarke Abel *, it differs from prehnite in being infusible.

It is probable that the agalmatolite, called by Werner *beildstein*, is in reality a softer kind of nephrite or axe-stone. These minerals are all nearly allied to serpentine.

Sp. 9. OBSIDIAN.

Pearly Obsidian, or Pearl Stone.

Obsidian, *Lave Vitrieuse Obsidienne*, Haüy.—This mineral bears a striking resemblance to black or dark-green glass, having the perfect vitreous lustre, and conchoidal fracture of glass; internally the lustre is splendent; it breaks into very sharp-edged fragments, and is more or less translucent. Its hardness is

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* Narrative of a Journey to the Interior of China.

less than that of felspar, but greater than window-glass. The specific gravity is from 2.35 to near 2.40. It is fusible into a spongy glass.

Obsidian always occurs massive or in roundish-shaped pieces; it forms beds of considerable extent in volcanic countries, and may be observed forming congealed currents that have flowed from volcanoes, and which can be traced in many instances to their craters. It may be seen passing into compact lava, basalt, and pumice. Obsidian sometimes forms the basis of porphyry in mountainous countries, that have long ceased to be the seat of volcanic fire. According to the observations of Cordier, obsidian, though apparently a simple homogeneous mineral, is in reality composed of minute grains and crystals of certain minerals found in all lavas. These grains may be detected in obsidian with a high magnifying power; they are either felspar or augit; and hence it may be divided into two kinds. 1st, Obsidian, which melts into a white glass, is principally composed of grains of felspar; 2d, that which melts into black glass contains a large portion of grains of augite. From this difference, results, as might be expected, a considerable variation in the analyses of obsidian. The constituent parts of American and Iceland obsidian, as given by different chemists, are,

	Iceland.		Mexico.		
Silex -	63	78	74	71	72
Alumine -	20.5	10	14	13.4	12.5
Iron -	13.5	2	—	——	——
Manganese	——	1.6	3	4	2
Lime -	——	1	1.3	1	0
Potash -	——	6	3.3	4	10
	97	98.6	95.6	93.4	96.5
Loss -	3	1.4	4.4	6.6	3.5
	By Tromsdorf.	Vauquelin.	Drappier.	Drappier.	Descotils

It has been observed, that when obsidian undergoes fusion, it is very much increased in bulk, and forms a spongy or vesicular glass. Humboldt is of opinion, that a gas is evolved during its fusion; and he attributes the earthquakes in the Cordilleras to the extrication of this gas.

Obsidian appears to be lava, or basalt, that has acquired a vitreous state from rapid refrigeration; a similar effect is produced when lava or basalt is melted in a furnace and suddenly cooled; and if the vitreous mass be remelted and cooled more slowly, it is converted into a substance nearly resembling the original basalt, or lava, from which the volcanic glass was formed. It is the opinion of some mineralogists, that obsidian or volcanic glass is not formed by existing volcanoes; but it may be observed in the crater of Vulcano, a volcanic island near Lipari; and I have a specimen of black lava very compact, that flowed from Vesuvius in 1817, which is passing in one part into obsidian.

Obsidian is found in many of the volcanic islands of the Mediterranean, particularly in Lipari, where, according to Spallanzani, an entire mountain composed of beds of obsidian may be seen near the city of Campo Bianco. The thickness of the beds is variable; they contain round cavities, which are sometimes traversed by fine vitreous filaments. A current of obsidian may be traced from the crater of an extinct volcano to the sea-shores in Felicuda, another of the Lipari islands. Currents and masses of obsidian exist among the volcanic mountains in Iceland. Obsidian also occurs near Tokay, in Hungary, and in Spain. Black obsidian porphyry occurs in large quantities near the summit of the peak of Teneriffe. Obsidian is found on the continent of Asia, in Siberia, and in Kamschatka; it has been observed in various volcanic islands in the South Sea; and it occurs in great quantities in Mexico and in Peru. In some of the Andes, it has been observed at the height of 15,000 feet. Rounded masses of obsidian sometimes are found in pumice. In the island of Ponza, according to Brongniart, plates of yellow mica with white vitreous grains, supposed to be felspar, are inclosed in balls of obsidian. In Mexico and Peru, black obsidian was made into mirrors and various ornaments, and even into knives and razors.

Pearl-Stone, *Obsidienne Perlée*, and *Lave vitrieuse Perlée*, is of a grey colour, sometimes passing from pearl-grey into blackish-grey, and reddish-brown or red; it has a shining pearly lustre, and is more or less translucent. Pearl-stone occurs forming beds, and imbedded or intermixed with felspar, quartz, and mica; it consists of adhering globular concretions, which are composed of thin concentric laminæ, and sometimes inclose obsidian in the centre. The larger globular concretions have a smooth and pearly surface, resembling that of pearl. Pearl-stone is easily broken, and is softer than common obsidian; but its specific gravity and constituent parts are nearly the same, except that pearl-stone contains a certain portion of water in its composition. According to Klaproth, pearl-stone contains — Silex 77.25, Alumine 12.00, Oxide of Iron 1, Potash 4.50, Lime .50, Water 4.50.

Pearl-stone probably differs from obsidian, owing to water having had access to subterranean fire at the period of its formation; this appears to be frequently the case during volcanic eruptions. Pearl-stone occurs in volcanic rocks, or in porphyry, and basalt, supposed to have had a volcanic origin; it is frequently associated with obsidian. This mineral has been found near Sandy Brae, in Ireland.

Obsidian cannot be confounded with any other mineral but pitch-stone, into which it passes, and is nearly allied. Pitch-stone has less lustre than obsidian, and it inclines to resinous, whereas that of obsidian is splendent and vitreous. Obsidian is also more translucent than pitch-stone, and the fracture more perfectly conchoidal. Pitch-stone ought probably to be classed as a species of obsidian, but as its igneous origin may be more doubtful, it has been thought better to arrange them as distinct species.

Sp. 10. PITCH-STONE.

Pitch-stone, *Retinite*, Brongniart. — This mineral derives its name from the striking resemblance some of the varieties bear to pitch, in colour and lustre. Its prevailing colours are, blackish-green, green, black, and brown; and the lustre is resinous or vitreo-resinous. Pitch-stone is feebly translucent at the edges; the specific gravity varies from 2.19 to 2.38; it is softer than felspar, and is fusible. The constituent parts, as given by Klaproth, are — Silex 73, Alumine 14.50, Lime 1, Oxide of Iron 1, Oxide of Manganese 0.10, Soda 1.75, Water 8.50.

Pitch-stone occurs massive, forming entire beds of rock; sometimes it is found in veins. It breaks with an imperfectly conchoidal fracture, and presents no appearance of an internal crystalline structure; but on a large scale it is sometimes columnar. A lofty promontory, called the Scuir of Egg, one of the Scotch Hebrides, is composed of magnificent ranges of columnar pitch-stone, which, according to the account of Dr. Macculloch, exceed in grandeur and picturesque effect the basaltic columns of Staffa. The pitch-stone is black and porphyritic, containing imbedded crystals of glassy felspar. Pitch-stone occurs in large veins in the isle of Arran, and is found in various basaltic and volcanic districts on the continent of Europe, and in Mexico and South America.

Distinctive Characters. — Pitch-stone may be distinguished from semi-opal by the dullness of its colours and its fusibility. Its low degree of specific gravity and inferior hardness, distinguish it from chert or hornstone; the characters which distinguish pitch-stone from obsidian have been already given.

Sp. 11. CHIASTOLITE.

Chiastolite, or Hollow Spar, *Macle.* This singular mineral occurs in rhomboidal, or nearly cylindrical prisms, that are externally white or grey, but which inclose an internal prism of a dark colour, and similar to the rock in which the crystals are imbedded; this is dark-slate (clay-slate). Plate IV. fig. 28. represents a prism of chiastolite with a small dark-coloured prism inclosed. In some instances, there are dark lines running from the angles of the inner prism to those of the outer, as represented in this figure; and in other instances, a number of black lines also run parallel with all the edges of the prism. Sometimes four smaller black prisms are formed within each angle of the outer prism. The crystals are sometimes acicular and sometimes large; the white part has a laminar structure, a glistening lustre, and is translucent. Its specific gravity is 2.92, and it is as hard as felspar; it is infusible. Chiastolite occurs in acicular crystals in dark slate on Skiddaw, in Cumberland. The largest crystals of this mineral are found in clay-slate, near St. Brieux, in Britanny.

There are prisms of chiastolite, in the British Museum, an inch in diameter, exhibiting distinctly the internal structure described above.

It can scarcely be doubted that the external and internal crystals were formed at the same time; for we cannot suppose that the prisms were first formed hollow, and afterwards filled with the clay-slate.

SP. 12. HORNBLENDE, or AMPHIBOLE.*

1. *Common Hornblende.*	3. *Actynolite.*
2. *Basaltic Hornblende.*	*Glassy Actynolite.*

COMMON HORNBLENDE.—Hornblende is a constituent part of many compound or aggregated rocks; it also forms entire beds and masses of great extent and magnitude; it sometimes occurs crystallized, but is more frequently amorphous, with an internal crystalline structure, which is either laminar or fibrous; the fibres are sometimes broad, and sometimes acicular, and are often confusedly aggregated, and intersect each other in every direction. The common colour of hornblende is greenish-black, dark bottle-green, or brown; it has internally a

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* Hornblende, this unmeaning term, is perhaps less objectionable than that of amphibole (or ambiguous) given to this mineral by Haüy. Mr. Kirwan says, that the miners, expecting to find some metal in hornblende besides iron, and being disappointed, called it *blind;* in the same way *blende* or *blind* is applied to some other minerals. Were Dean Swift to arise and review the language of mineralogists, he would probably derive hornblende or *hornblind* from Vulcan, as a name given to that god from the cause of his blindness, described in the well-known English ballad, where he is represented assailing his rival Mars with jealous fury: —

> But his broad horns did stand so in his sight,
> He could not see to aim his blows aright.

Such a derivation would be as appropriate, and convey as much meaning, as the names of many minerals recently introduced.

shining and somewhat pearly or resinous lustre; it is opaque, except the green varieties, which are translucent on the edges. When hornblende is scraped or pulverized, the colour of the powder is greenish-grey. It is softer than felspar, and scratches window-glass feebly. The specific gravity is from 3.20 to 3.28. It melts with great ease before the blow-pipe into a blackish-coloured glass. According to Klaproth, hornblende contains — Silex 42, Alumine 12, Lime 11, Magnesia 2.25, Oxide of Iron 30, Ferruginous Manganese 0.25, Water 75. Common hornblende does not often occur in distinct crystals, but when its structure is sufficiently regular, it may be split in two directions parallel to the sides of an oblique four-sided prism. The obtuse angle formed by the incidence of the face of the primitive crystal (Plate IV. fig. 23.), M on M is 124½°, and the acute angle of the prism 55½°, and the angle formed by the terminal plane P, with the edge H, is 105°. The cross fracture of hornblende is uneven.

The secondary crystals are long, oblique, four-sided, or six-sided prisms; the terminations of the prisms are described under the variety basaltic-hornblende.

Hornblende Slate. — Common massive hornblende, either composed of fibres or of laminæ, forms beds in primitive mountains, which have a slaty structure, and are called *hornblende slate.*

Some varieties of hornblende-slate have a lustre resembling that of velvet. Well-characterised hornblende-slate, is very common in the Highlands of Scotland, but it is not met with distinctly characterised in England or Wales. Common hornblende occurs in large quantities, and in masses of considerable size at the Malvern Hills in Worcestershire; it is intermixed with epidote and felspar. Hornblende occurs as a constituent part of sienite and greenstone, at Charnwood Forest, in Leicestershire, and in various parts of Devonshire, Cornwall, Wales, and Cumberland, and in almost all alpine districts that have been examined. It sometimes occurs in granite and gneiss, and is a component ingredient in many volcanic rocks.

BASALTIC HORNBLENDE.—This variety is generally distinguished by its splendent lustre, its deep black colour, and the more perfect form of its crystals. It is also more brittle and less easily fusible than common hornblende, and the structure is more distinctly laminar. It occurs in imbedded distinct crystals, in lava and basalt, and in masses and groups of irregular crystals among volcanic rocks. The surfaces of the crystals are smooth; they are generally irregular six-sided prisms. Sometimes the prisms are terminated at each extremity by three rhombic faces, forming in the whole twelve faces; this crystal is the amphibole dodecahedre of Haüy.

Another variety, called *amphibole equidifferent* (see Plate IV. fig. 24), consists of a six-sided prism, terminated at one extremity by four trapeziums, and on the other by two pentagons. Both common and basaltic hornblende are liable to decomposition on the surface, and are sometimes covered with an ocherous incrustation. Basaltic hornblende contains — Silex 47, Alumine 26, Lime 8, Magnesia 2, Oxide of Iron 15, Water 0.5. Klaproth.

ACTYNOLITE, *Amphibole, Actinote.*—Actynolite is classed by Werner as a distinct species, but is considered by Haüy as a variety of amphibole or hornblende, with which it agrees in the form of the primitive crystal, and other essential characters. Actynolite may be regarded as the purest form of hornblende; it has a greater degree of translucency, and a more vivid green colour, which appears by analysis to be derived from the oxide of chrome. Actynolite most frequently occurs in wedge-shaped concretions, composed of long slender hexahedral prisms. Sometimes the prisms are acicular; in other instances, flat and broad. They are parallel or radiated, and sometimes intersect each other. The fibres feel particularly harsh, when the finger is passed along them.

Actynolite is brittle in the transverse direction of the crystals, but they are sufficiently hard to scratch glass. Before the blow-pipe, it melts into a greenish-grey glass. The constituent parts are — Silex 50, Magnesia, Lime 9.75, Alumine 0.75, Oxide of Iron 11, Oxide of Chrome 5, Water 3. Langier.—An analysis of common actynolite, by Bergmann, gives—Silex 64, Magnesia 20, Alumine 2.70, Lime 9.30, Iron 4.

Actynolite sometimes occurs lamellar or granular.

GLASSY ACTYNOLITE is the variety that occurs in acicular crystals; they are frequently parallel, and are sometimes bent or waved. It has a shining vitreous lustre. When the crystals are extremely minute or fibrous, it passes into a variety called asbestous actynolite.

ASBESTOUS ACTYNOLITE, *Actinote Aciculaire*, occurs in radiated, diverging, wedge-shaped concretions; it is softer than the other varieties of actynolite, and seems to be approaching to the state of amianthus; the colour is a greyish-green or brown. It is found near Marazion, in Cornwall, and in various parts of the continent of Europe. Some varieties of fibrous actynolite have the fibres parallel and slightly adhering, and approach still nearer to amianthus; but the fibres are more harsh and brittle. Asbestous actynolite is found in Cornwall, and at Glenelg in Aberdeenshire, and in various parts of Europe.

Amphibole, including the varieties of hornblende and actynolite, possess the following characters.

Specific Gravity exceeding 3.

Hardness inferior to felspar.

Fusible with ease before the blow-pipe, into a blackish or greenish glass.

Form. — Crystallized; confusedly crystallized and aggregated; disseminated in rocks; or massive and amorphous; primitive form, a low rhomboidal prism (p. 293). Secondary crystals generally long hexahedral prisms, either flat or acicular, and radiated, intersecting, or parallel.

Structure and Fracture, more or less distinctly laminar; the laminæ often promiscuously fibrous or radiated. Twofold cleavage distinct in the direction of the sides of an oblique prism. Cross-fracture granularly uneven.

Affections of Light. — Colours dark-green, black, and brown; green variety translucent; when crystallized, sometimes transparent; black and massive varieties opaque.

Distinctive Characters. — Hornblende, particularly basaltic hornblende, has not unfrequently been confounded with black schorl (tourmaline), from which it may be distinguished by its inferior hardness, its fusibility, and its laminar structure; the surface of the crystals of basaltic hornblende is smooth, of schorl generally deeply striated. Augite or pyroxene has been more frequently mistaken for hornblende; but augite is imperfectly fusible; it is harder than hornblende, and the angles of its cleavages are 92° and 88°. Hornblende is less hard than epidote; the latter is only fusible into a brownish or blackish slagg, whereas hornblende melts easily into black glass. The cleavage of epidote forms angles of 144½° and of 65½°, which vary ten degrees from the angles formed by the cleavage of hornblende.

Fibrous hornblende will not form a powder soft to the touch, like that of asbestus. Hornblende differs in colour from tremolite, the latter being a light grey, or nearly white; but it is regarded by Haüy as a variety of hornblende.

Sp. 13. TREMOLITE?

Tremolite, *Amphibole Grammatite,* Haüy.—This mineral might not improperly be called white-actynolite; it was called tremolite, from being originally found in the valley of Tremola, a part of St. Gothard, whence the finest specimens are still procured. It occurs in a white granular magnesian lime-stone (dolomite), and contains a large admixture of the carbonate of lime and magnesia, but which are supposed not to be chemically combined with it. Tremolite is considered by Haüy as a variety of actynolite (*amphibole*), having the same form of the primitive crystal; and the form and structure of the secondary prisms of tremolite and actynolite are nearly the same; but the colours of tremolite incline to white, or light grey, and those of amphibole to dark-green or black. The proportion of lime and magnesia is much greater in tremolite; but this, as mentioned above, is supposed to be, for the most part at least, a mechanical admixture. According to the Count de Bournon, the primitive form of the crystal varies from amphibole, being a four-sided rhomboidal prism, with alternate angles of 126° 52′, and 53° 8′, and the terminal planes are perpendicular to the axis of the prism. The cleavage is in the direction of the sides, and also of the diagonals; but more easily in that of the greater diagonal; it also cleaves, but less easily, in a direction parallel to that of the terminal planes. In breaking one of the prisms of tremolite across, we may observe a line in the direction of the greater diagonal, so strongly marked, that Haüy gave this mineral the name of *grammatite,* which implies *marked with a line.*

Tremolite sometimes occurs in single crystals, but more frequently in concretions, composed of long compressed prisms, with four, six, or eight sides, and closely adhering. The prisms are generally radiated or diverging. Sometimes the crystals are acicular or fibrous, and the fibres are either radiated, diverging, or parallel. The prevailing colour is greyish or greenish-white; it has a pearly lustre, and is translucent. The specific gravity is from 2.82 to 3.00. Though exceedingly brittle, the terminal edges of the prisms will frequently scratch quartz. Before the blow-pipe, it fuses with great difficulty. The following varieties of tremolite differ from each other, in the form and arrangement of the fibres, in the same manner as already described in the varieties of actynolite.

ASBESTOUS TREMOLITE occurs in wedge-shaped masses, composed of radiated or stellular fibres; it differs from asbestous actynolite in colour, which is a greyish-white.

Glassy Tremolite occurs in acicular crystals, or in masses composed of acicular crystals, which are more or less diverging, or nearly parallel; they are intersected by transverse seams; it has a shining pearly lustre.

The constituent parts of tremolite, though given by different analysists, are still uncertain, as the lime and magnesia are mechanically intermixed. They are stated — Silex 28 to 64, Magnesia 10 to 18, Lime 15 to 26, Carbonic acid and Water 6 to 23. These variations show, that we are still unacquainted with the proportions of the true constituent ingredients of tremolite. All the varieties of this mineral have a tendency to divide into minute fibres; they may be distinguished from amianthus by the harsh feel of the fibres. Tremolite phosphoresces when scraped, but this is supposed to be owing to the intermixture of dolomite, in which it is generally imbedded. Tremolite has been found with actynolite at Glenelg, in Inverness-shire, and in dolomite at Glentilt. Asbestous actynolite has been found in the Castle rock at Edinburgh, and in granular lime-stone on Mount Vesuvius. Tremolite also occurs in various parts of the continent of Europe. Its principal repository is granular lime-stone; and it ought, perhaps, to be regarded as amphibole merely changed by contiguity to lime-stone, at the period of its formation.

Sp. 14. AUGITE, or PYROXENE.

1. *Common Augite.*
2. *Granular Augite.*
3. *Diopside, or Mussite.*
4. *Laminar Augite, or Sahlite.*

Augite. — Nothing can more clearly evince the crude notions respecting the formation of crystallized minerals, entertained by mineralogists at the beginning of the present century, than the name *pyroxene,* given by M. Haüy to augite. This name, which implies a stranger to fire, or, as that distinguished philosopher translates it, "*Etranger dans le domain de feu,*" was particularly inappropriate, as applied to a mineral which forms a constituent part of almost all dark-coloured volcanic rocks, whether of ancient or recent date. Philosophers at that period had paid little attention to the results of crystallization from fusion; hence the crystals found in lava and many other rocks, were supposed to have had a prior origin to the matter in which they are imbedded, and to have been subsequently enveloped by it; hence too vesuvian and many other minerals, are stated by M. Haüy to be found in ejected masses of primitive rocks, which have undergone no alteration by fire;—an error which has been copied by almost all succeeding writers.

COMMON AUGITE occurs crystallized, and amorphous, in basaltic and volcanic rocks; it sometimes exists in very minute grains disseminated through these rocks, of which it forms a principal part, associated with felspar, olivine, and other minerals. Augite also forms entire rocks of considerable extent, either alone or intermixed with felspar. This mineral has often been mistaken for hornblende, by earlier geologists, and when uncrystallized, it is not always easy to ascertain the difference by mere inspection. The colours of augite are generally blackish-green, or greenish-black; it is sometimes brownish or greyish-green, or reddish-brown. The varieties that incline to black, are nearly opaque. The green are more or less translucent, and sometimes transparent, and these have frequently been mistaken for olivine; they are not uncommon in some of the lavas from Vesuvius.

The lustre of augite is resinous, of various degrees of intensity, and is sometimes splendent in the fresh fracture; its specific gravity is about 3.25; its hardness is less than that of felspar. Before the blow-pipe, augite melts into a black enamel with extreme difficulty, and only in minute portions; this property distinguishes it from hornblende. The crystals of augite are often very distinct; the primitive form is an oblique rhomboidal prism (Plate IV. fig. 9.); the alternate angles formed by the inclination of the sides are 87° 42′ and 92° 18′; and the angle formed by the base P with the edge H is 106° 6′. The secondary forms are generally irregular six or eight-sided prisms, terminated by two planes at each extremity, as represented in Plate IV. fig. 22. Sometimes all the edges are truncated or bevelled, producing a great number of planes; sometimes two and sometimes four of the sides are broader than the rest. Crystals of augite also occur hemitrope, and sometimes they cross each other. The structure is laminar, with joints parallel to the planes and diagonals of the primitive crystal (fig. 9.); the cleavages parallel to the sides of the prisms are the most distinct. The cross fracture is conchoidal.

The constituent parts of augite are given as under:

From	Silex.	Alumine.	Lime.	Magnesia.	Iron.	Mang.	
Etna - -	52.	3.83	13.2	10.	14.16	2	Vauquelin.
Frascati -	48.	5.	24.	8.75	12	1	Klaproth.
Piedmont *Mussite* -	57.	—	18.5	18.25.	8	—	Langier.
Arendal -	50.	1.5	24.	10.00	7	3	Vauquelin.
Sahlite -	53.	3.	20.	19.	4	—	Vauquelin.

COCCOLITE, OF GRANULAR AUGITE, *Pyroxene Granuliforme*, occurs in slightly cohering granular concretions, sometimes very small, and seldom larger than a pea; the structure is laminar, and the lustre shining and vitreous. The colour of coccolite is various shades of green. It was first found in Norway, and considered as a distinct species, but is now classed by Haüy with augite. According to Professor Cleaveland, coccolite has been found in various parts of the United States, in large masses and of various colours, as black, brown, and red.

DIOPSIDE, MUSSITE, and ALALITE, are names given to certain minerals found in the plain of Mussa, and at Ala in Piedmont. These are, according to Haüy, different varieties of pyroxene, or augite, of which they sometimes preserve the primitive form. According to their greater or less degree of purity, they pass into each other and into sahlite. The colours are pale greyish-green, and of the small crystals bright-green. Diopside, beside occurring in the primitive form of augite, also occurs in compressed prisms or tables, or in long prisms which are deeply streaked and nearly cylindrical (*Pyroxene cylindroide,* Haüy). Sometimes the long compressed prisms are collected in groups, which are either parallel or diverging, and are often adhering to amorphous masses of the same substance, which are either granular, laminar, or nearly compact.

SAHLITE, *Pyroxene laminaire gris verdatre,* Haüy, *Malacolite,* Brongniart. — The colours are greyish-green; it occurs crystallized in four-sided or eight-sided prisms, but more frequently in laminar masses, which have cleavages parallel to all the planes, and the two diagonals of a four-sided prism. According to Haüy, the inclination of the lateral planes form angles, as in augite, of 87½° and 92½°. The Count de Bournon denies the identity of the crystalline primitive forms of sahlite and augite, but his objections have been answered by M. Haüy.

The cleavage of sahlite is more easily effected in the direction of the terminal, than in that of the lateral planes, the reverse is the case with augite. The specific gravity of sahlite and augite are the same, but sahlite is softer. Sahlite was first found near Sahla in Sweden. It occurs at Glentilt and Glenelg in Scotland.

Distinctive Characters of Augite. — Augite occurs in similar situations, and bears a great resemblance to basaltic hornblende, but the latter has a deep velvet-black colour, and is always opaque. Basaltic hornblende is harder and more easily fusible than augite; the hardness of augite being the same as of common hornblende. Augite differs in crystallization and cleavage from epidote, and is also softer. Olivine rarely occurs crystallized, and is generally more transparent than augite, and has a lighter range of colours, and is infusible.

SP. 15. EPIDOTE, or THALLITE.

Crystallized Epidote.
Compact Epidote.
Granular Epidote.
Zoisite.
Manganesiferous Epidote.

This mineral has received a greater variety of names than almost any other. *

Epidote is not unfrequent in alpine districts, either in crystals, or in groups, or forming veins, which are generally small; indeed epidote rarely occurs in masses of considerable size. Professor Cleaveland, however, mentions veins of epidote more than a foot in width, which traverse granite in the county of Brunswick, in the United States. The prevailing colours of epidote are yellowish or blackish-green. It occurs crystallized and amorphous. The amorphous varieties are sometimes granular and sometimes compact. The primitive crystal of epidote, according to Haüy, is a right four-sided prism, the bases of which are oblique-angled parallelograms. The distinct cleavages are parallel to the sides of the prism, and meet under angles of 114° 37′ and 65° 23′. The sides of the base are to the height, in the proportions of 8 and 9 to 5. The cross fracture is fine-grained. The forms of the

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* Pistazite, *Werner*; Dalphinite, *Saussure*; Thallite, Acanticone, Arendalite, Schorl-vert, &c. of other mineralogists.

secondary crystals of epidote are numerous; they are generally prisms which have six, eight, or a greater number of sides; but the faces belonging to the primitive prism that remain uncovered, are larger than the others.

Haüy divides crystallized epidote into three varieties. 1st, Green crystals, generally long and slender; these are the pistazite and thallite of some mineralogists. 2d, Green or blackish-green crystals, often of considerable size; these come from Arendal in Norway, and have been called acanticone and arendalite; and 3d, Splendent, purplish-grey or brown, commonly incomplete at the extremities, called zoisite. The following are the common secondary forms of epidote. A six-sided prism terminated at each extremity by two planes, forming with each other an angle of 110° 6′ at the summit, and with the narrow sides of the prism on which they stand, angles of 124° 37′. See Plate IV. fig. 14.; this is the *epidote bisunitaire* of Haüy. Fig. 15. is the *epidote menostique;* and fig. 16. *epidote dissimilaire*, so called from the dissimilarity of the terminations of the prism; a great variety of other modifications of the prism occur in epidote. The crystals are often slender and sometimes acicular, and collected into masses or concretions, in which they are arranged, either diverging or parallel. In the latter case, the structure appears fibrous; more perfect crystals of epidote are generally attached to some part of these concretions. The epidote in veins has frequently a granular structure, but is sometimes compact. The specific gravity of epidote is from 3.40 to 3.45. Its hardness equal to felspar. Epidote is more or less translucent, the lustre is vitreous, and varies from glistening to splendent. Before the blow-pipe, it forms a brownish-coloured scoria. The constituent parts of epidote, as given by Vauquelin, are—Silex 37, Alumine 21, Lime 15, Oxide of Iron 24, of Manganese 1.5, Water 1.5. In the epidote from the Valais, there was Silex 37, Alumine 27, Lime 20, Oxide of Iron 13, of Manganese 0.6, Water 1.8.

Skorza, a name given to green vitreous grains which have all the characters of epidote; they are found on the bank of the river Arangos near Muska, in Transylvania, and have been analysed by Klaproth.

Zoisite, a variety of epidote, which has received its name from Baron von Zois, of Laybach. Its prevailing colours are blueish or yellowish; it occurs amorphous, and in crystals which are long four-sided prisms, they are striated, and the terminations incomplete; the structure is laminar, and the lustre pearly. According to Klaproth, it contains — Silex 42, Alumine 29, Lime 21, Oxide of Iron 3.

Zoisite appears to differ from epidote by the small portion of iron, to which circumstance its lighter colours are probably to be attributed. It was first discovered in Carinthia. It has been found also at Glenelg in Inverness-shire.

Epidote occurs in various parts of the world; in England, it has been found forming veins in quartz at Wallow Cragg, near Keswick in Cumberland. At the Malvern Hills in Worcestershire, it occurs imbedded in sienite, and forms small veins, which traverse the rocks in various parts of the range. It has also been found in some parts of Cornwall. Epidote forms a constituent part of some rocks, and sometimes, as before stated, fills entire veins; it is often associated in veins or beds with garnet, hornblende, felspar, augite, and calcareous spar, with iron pyrites and ores of copper.

MANGANESIFEROUS, or VIOLET-COLOURED EPIDOTE, was discovered by M. Cordier, at St. Manel in Piedmont, in a bed of manganese, from which it has evidently taken its colour; it contains 12 per cent. of manganese. A massive specimen in the British Museum, has a deep violet colour inclining to reddish-brown; the structure is laminar or fibrous, and promiscuously diverging.

Specific Gravity of epidote 3.40 to 3.64.

Hardness equal to felspar, scratches hornblende.

Imperfectly fusible, forms a brown scoria by the blowpipe.

Form. — In crystals, and in crystalline concretions, amorphous; primitive crystal a right four-sided prism; secondary crystals, prismatic, generally long (see the description before given).

Structure and Fracture. — Of the crystals laminar, with a cleavage parallel to the sides of the primitive crystal; cross-fracture uneven and granular; crystalline masses diverging, radiated, or fibrous or granular, amorphous masses and veins sometimes compact.

Affections of Light. — Colours light or dark green (of zoisite light-grey); nearly transparent to feebly translucent; lustre varying from splendent to glistening, vitreous, or resinous.

Distinctive Characters of Epidote. — Epidote has frequently been mistaken for actynolite or hornblende, but it is considerably harder and much less fusible. The angles formed by the cleavages of epidote differ ten degrees from those of hornblende or actynolite. Its lustre is also more vitreous than that of hornblende. Epidote is harder than asbestus; the latter fuses into an enamel, and the powder is soft, and that of epidote is rough. Epidote is harder than augite; the form of the crystals differ, and the colours of epidote are generally lighter.

OBSERVATIONS ON AMPHIBOLE, AUGITE, AND EPIDOTE.

Notwithstanding the difference in crystalline structure observed in these minerals, yet we cannot but indulge the expectation, that a further and more accurate investigation may unite them as varieties of the same species; a union which would remove much obscurity from the descriptions of geologists. Haüy even admits, that the structure of augite and amphibole may be brought very nearly to coincide, by admitting certain laws of decrement. (*Tableau Comparatif*, 179.) The physical properties, chemical composition, and geological situation of these minerals, so nearly agree, that their union as one species would render this department of mineralogy more simple and intelligible: their separation into distinct species has hitherto been attended with no advantage, but that of giving the experienced mineralogist the frequent opportunity of appearing wise.

Sp. 16. DIALLAGE.

1. *Smaragdite, or bright-green Diallage.*
2. *Schiller Spar, or dark-green Diallage.*
3. *Diallage Metalloide, or Bronzite.*

Diallage generally occurs in laminar concretions, imbedded in saussurite, compact felspar, or serpentine, and sometimes in other rocks. The structure is laminar, or fibrously laminar, with a very distinct cleavage in one direction, forming smooth and shining faces, with a lustre varying from silky to pseudo metallic; the cleavages in the other directions are dull. According to Count de Bournon, the primitive crystal of diallage may be considered as a rhomboidal four-sided prism, with alternate angles of 95° and 85° ; the planes which have the metallic lustre being parallel to two opposite sides of the prism. These two shining lateral planes are larger than the other, and are described by some mineralogists as the terminal planes. According to Haüy, it has also two cleavages parallel with the diagonals of the prism.

The specific gravity of diallage is about 3.10. The hardness is variable, being equal to that of felspar in some, and less in other varieties.

Diallage has only one very distinct cleavage; it differs in this character from felspar and other minerals, with which it might be sometimes confounded. The name diallage was given to this mineral by Haüy, from the Greek word which implies difference.* The varieties of diallage vary so much in colour and lustre that they have been classed by some mineralogists as distinct species; but in an interesting note in the *Tableau Comparatif,* p. 191, M. Haüy states, that the silky lustre of the green diallage sometimes passes into the splendent grey metallic lustre of the other varieties. One specimen in the col-

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* Alluding to the different lustre of the joints.

lection of M. Haüy presents diallage of a beautiful green, passing to a splendent metallic grey; the natural joints of the green part are continued into the metallic part, so as to leave no doubt that they are both the same substance, which by some accidental cause has assumed a different colour and lustre. In other instances, laminar concretions of diallage imbedded in saussurite may be observed passing through all the gradations of lustre and colour from the green to the metallic.

I have specimens from the Lizard in Cornwall, in which parts of the same laminæ have the steel-grey metallic lustre, and other parts a copper or bronze colour, forming bronzite. It is observed by Haüy, that diallage metalloide appears to pass by insensible gradations into a schiller spar, a mineral generally found in serpentine. These observations seem to confirm the propriety of regarding smaragdite, diallage metalloide, and schiller-spar, as belonging to the same species.

Smaragdite has a bright apple-green or grass-green colour, a silky and glistening lustre, and is feebly translucent. It has a distinct laminar structure in one direction; sometimes the laminæ are fibrous. Its hardness is about the same as that of hornblende. Smaragdite frequently occurs imbedded in saussurite or compact felspar, and is sometimes in masses composed of granular concretions, or nearly compact. Its constituent parts are — Silex 50, Alumine 11, Magnesia 6, Lime 13, Chrome 7.05, Iron 6.30, Copper 1.50.

Smaragdite is found in Switzerland, in the Island of Corsica, in Carinthia, and in Transylvania. The smaragdite of Corsica, intermixed with suassurite, is called by artists *Verde de Corsica duro*, and has been named Euphotide by Haüy.

SCHILLER-SPAR is regarded by many mineralogists as crystallized serpentine, in which rock it generally occurs imbedded in distinct laminæ; the colours are dark green, and the lustre shining or splendent and metallic; sometimes it is of a paler green, and the lustre is splendent and pearly: in this form, it occurs in beds of translucent serpentine, in Anglesea. The metallic lustre appears to arise from an incipient decomposition, the lustre being frequently variable. In the collection of the Count de Bournon, there were specimens both of green and bronze diallage, which had changed to a reddish-brown. Schiller spar is sometimes found in rocks of trap.

Diallage Metalloide has a metallic lustre, varying from steel-grey to a bronze colour in the same specimen: when of the latter colour it is called bronzite; both these varieties of colour occur well defined near the Lizard in Cornwall, varying in lustre from nearly splendent to glistening, and having a distinct laminar structure, with indications of cleavages in other directions parallel to the sides of a rhomboidal prism; but the surfaces produced by the latter cleavages are dull. It occurs in laminar concretions disseminated through a rock of greenish-white disintegrated felspar, which appears to be an intermediate substance between felspar and steatite, and is probably an original formation. The constituent parts of diallage metalloide are,

Silex.	Alumine.	Lime.	Magnes.	Iron.	
60	——	—	27.5	10.5	Klaproth.
41	3	1	28	14	Drapier.
43.7	17.19	—	11.2	23.7	Gmelin.

SP. 17. HYPERSTENE.

Anthophylite.

HYPERSTENE, *Labrador Hornblende.*—This mineral is distinguished by its red chatoyant pseudo-metallic lustre, when viewed in certain directions; in other directions, it appears brownish or greenish-black, and is opaque. The specific gravity is about 3.40; the hardness equal to felspar. The structure of hyperstene is laminar; it has cleavages parallel to the sides, and diagonal of a rhomboidal prism; the angles formed by the sides, according to Haüy and Bournon, are 100° and 80°. Hyperstene is infusible before the blow-pipe. The constituent parts, according to Klaproth, are — Silex 54.25, Magnesia 15, Alumine 2.25, Lime 1.50, Oxide of Iron 24.50, Water 1, and a trace of Manganese. This mineral has not been found crystallized; it was brought from the coast of Labrador, where it forms a constituent part of a sienitic-rock, composed of felspar and hornblende, associated with magnetic iron-stone. It has also been discovered by Dr. Macculloch, forming part of a rock of sienite, in the Isle of Skye, and also near Portsoy.

The greater specific gravity, darker colours, and infusibility, distinguish hyperstene from Labrador felspar.

Anthophylite appears nearly allied to hyperstene; but it has little of the pseudo-metallic lustre, which distinguishes the latter mineral. The specific gravity is 3.29; hardness equal to felspar or hyperstene. The colour of anthophylite is a brownish-grey or reddish-brown; it is more or less translucent, and the lustre is shining or glistening, passing from pearly to pseudo-metallic. The structure is laminar or fibrously laminar, with two cleavages parallel to the planes of a quadrangular prism and two parallel to the diagonals; the former are more rarely obtained, and produce shining surfaces. Haüy supposes that the prisms are rectangular;

but some doubts remain respecting the angles, they are probably the same as those of hyperstene, with which it agrees in the nature of the constituent parts, but not in the proportions which are given by Johns, in two analyses.

Silex.	Alumine.	Lime.	Mag.	Iron.	Mang.
62.68	31.33	3.33	4.00	12	3.25
56.00	13.3	3.23	14	6	3

Anthophylite is infusible before the blowpipe, like hyperstene; it is said to be softer than the latter mineral, but on making the trial, the hardness of both was found to be equal to that of Labrador felspar. This mineral occurs amorphous with hornblende, at Kongsberg, in Norway.

ZEOLITIC MINERALS.

Observations. — In the collection belonging to the British Museum, all those minerals are arranged under the appropriate name of zeolitic substances, which were formerly called zeolites, but have since been divided by mineralogists into several distinct species. These minerals are nearly allied in composition and characters, and occur for the most part in similar situations, and some of them pass by gradation into each other. A difference observed or supposed in the form of the primitive crystal, has occasioned their separation into distinct species; and though this division may be admitted in the present state of our information, I have little doubt, that future observations will show the propriety of re-uniting several of these minerals under the same species. They are principally composed of silex and alumine, with lime or soda, and are combined with a large portion of water; their prevailing colour is white, with a pearly or nacry lustre. They have a low degree of specific gravity and hardness. They are all fusible before the blow-pipe, and many of them intumesce violently; hence the name zeolite, which was given by Cronstedt, from the Greek verb *zeo*, to boil. When powdered and dissolved in acids, several of the zeolitic minerals form a jelly. They are divided into the following species: Mesotype, (Dipyre? Natrolite?) Stilbite, Chabasie, Analcime, Prehnite, Harmotome, Apophylite, and Laumonite. These minerals never occur in large masses, but in single, or more frequently in aggregated crystals, and many of them are found in globular or mamillated concretions, which have frequently a diverging or radiated structure. Their general repository is in the cavities of basaltic amygdaloid, or of volcanic rocks. Their formation appears to be owing, in some instances, to the infiltration of water, or of gaseous exhalations, holding the constituent parts in solution. The formation of the delicate acicular or capillary crystals of zeolite, is probably analogous to that of the acicular crystals of nitre, formed on the surface of walls by atmospheric depositions. In some instances, the cavities in basalt are found filled with water when the stone is broken, and many zeolitic crystals are probably formed by depositions from the water in these cavities. If it should be asked, how water can possibly occur in the cavities of a rock like basalt, supposed to be of igneous origin, a simple experiment of Sir H. Davy will afford a satisfactory answer to the enquiry. He placed a piece of the basalt which contains water in its cavities, for some days, in the vicinity of a common fire, and on breaking it, he found the cavities empty; hence it is proved, that water can pass through the pores of basalt by slow infiltration, a circumstance which might have been anticipated; for even flint, though apparently so compact, has its pores filled with moisture, and we may observe dew upon the surface of a fresh fracture, when flint is first obtained from its native situation in the chalk rocks: further observations on the localities of these minerals, will be made in describing each of the different species.

Sp. 18. MESOTYPE.

Mesotype.—This mineral occurs crystallized, and more frequently in globular or mamillated concretions, composed of diverging or stellular crystals or fibres, which are sometimes slender and acicular, and sometimes broad and flat; these are closely adhering. Sometimes long distinct acicular crystals or capillary filaments, diverge from a centre at which they are united; these filaments are occasionally so delicately fine as to resemble cotton; these occur in the cavities of amygdaloid. The prevailing colour of mesotype is white, either pure or inclining to yellow, green, or red; it is translucent or transparent, and has a shining pearly lustre. Crystals of mesotype have a laminar structure with a double cleavage in the direction of one of the sides, and the base of a rectangular prism, which is the primitive form; it is nearly a cube, the length of the base being in proportion to the height as 9 to 8. The cross fracture of mesotype is conchoidal and vitreous. The common form of the secondary crystal is a long four-sided prism, terminated by low four-sided pyramids; the terminal planes are triangular and set on the lateral edges, and inclined to the lateral planes at angles of 174° 6′. The lateral planes are sometimes truncated, and some of the faces larger than the others. The acicular crystals of mesotype are sometimes called needle zeolite, or a needle-stone. The diverging or radiated structure is characteristic of the globular concretions of mesotype; these concretions break into wedge-shaped fragments. The specific gravity of mesotype is about 2.19; its hardness greater than calcareous spar. Before the blow-pipe, it melts with much ebullition into a white spongy enamel, and exhibits a slight degree of phosphorescence. It becomes electric by heat. When powdered, it dissolves slowly in acids and forms a jelly.

In the analysis of mesotype as given by different chemists, there is considerable variation in the proportion of the constituent parts; probably in some of the following analyses, other zeolitic minerals have been mistaken for mesotype.

Silex.	Alumine.	Lime.	Water.		
50	20	8	22.	—	Peltier.
49	27	—	9.5	17 soda.	Smithson.
54	30	8	2.	5 iron.	Klaproth.
41	31	11	16	—	Meyer.
50	29	10	10	—	Vauquelin.
60	24	10	2	—	

MEALY ZEOLITE, *Mesotype alterée aspect terreux*, Haüy, appears to be decomposing mesotype, and occurs in the same repositories, either amorphous, reniform, or coralloidal, and sometimes forming a crust over perfect mesotype; it is opaque and soft; the colours are yellowish or reddish-white, passing into red. It intumesces before the blow-pipe, and forms a jelly with acids.

Mesotype sometimes occurs of a brick-red colour, and has received the name of crocalite by some mineralogists; it occurs in fissures in basaltic-rocks.

Dipyre? *Schmelstein*, Werner. — This mineral has hitherto been found only near the river Maulein, in the Pyrenees: it occurs in slender octahedral prisms laterally adhering, forming what are called straight prismatic concretions; the lustre is vitreous inclining to pearly, the colour pearl; its other characters agree with mesotype.

Natrolite? is classed by some mineralogists with mesotype, with which it agrees in most of its characters, except that a large portion of soda (natron) enters into its composition, from whence the name *natrolite* was given to it by Klaproth, who states the constituent parts — Silex 48, Alumine 24.5, Soda 16.5, Water 9, Oxide of Iron 1.

Natrolite often occurs in basaltic rocks, in mamillated concretions, composed of slender, diverging, or radiated crystals or fibres closely adhering, as in mesotype and prehnite, and sometimes it appears nearly compact. It is distinguished by its colour, which is light-yellow inclining to brownish-red; the latter colour is often arranged in circular concentric stripes. Natrolite appears to be mesotype coloured by oxide of iron. It melts before the blow-pipe, and gelatinizes with acids. Crystals resembling mesotype, are often found in the small cavities of natrolite.

Natrolite has been found in the basaltic rocks of Scotland, and the islands of Mull and Canna.

Sp. 19. STILBITE.

Stilbite is distinguished by its splendent pearly lustre; its colour is generally white, and it is translucent or transparent; some varieties are yellow or red; it occurs crystallized and lamellar, and in masses composed of crystals grouped in bundles, or diverging like a fan; sometimes the masses are composed of laminæ closely adhering, appearing nearly compact; the lustre of these is less strong. The specific gravity is about 2.50. When perfectly sound it scratches glass feebly; it does not become electric by heat like zeolite, nor gelatinize in acids. Before the blow-pipe, it intumesces and melts into a vesicular glass. The constituent parts are — Silex 55, Alumine 17, Lime 8, Soda 1.50, Water 18. The primitive form of the crystal is a low right rectangular prism, the proportion of the sides of the base being as 3 and 5, and of the height 2. The structure is laminar, with one very distinct cleavage, parallel to two opposite sides of the prism. The secondary crystals are frequently four-sided prisms, terminated at each extremity by four planes set on the lateral edges, and the summit is sometimes truncated: this variety, called *stilbite epointée,* is represented in Plate IV. fig. 1. Sometimes the two sides which present the distinct cleavage, are so much broader than the others, that the crystal has a tabular appearance. Another variety is a low oblique four-sided prism, truncated on the acute lateral edges and on the obtuse angles, as represented in fig. 2.: this is the *stilbite anamorpheque* of Haüy. The obtuse angle formed by the inclination of the sides is 130° 24′. Stilbite is rather harder than mesotype, and has a higher lustre. It occurs in similar repositories with mesotype, and also in veins and fissures in primitive rocks. This species comprises some varieties of Werner's radiated and foliated zeolite.

Sp. 20. CHABASIE.

Chabasie.—This mineral occurs most frequently in the cavities of basaltic amygdaloid, generally crystallized; the crystals are sometimes rhombs approaching to the cube, which is the primitive form; the angles are 93° 48′ and 86° 12′. Sometimes all the obtuse lateral edges of the rhombs, and all the obtuse angles, are deeply truncated; this variety is called by Haüy *chabasie trirhomboidal,* and is represented Plate IV. fig. 4. In some instances, this form often undergoes further truncations. The crystals are seldom large. The prevailing colour of chabasie is greyish-white or yellowish-white; it is transparent or translucent. The external lustre of the crystals is splendent; it is internally glistening, and vitreous. The fracture is imperfectly laminar or conchoidal. The specific gravity is 2.71. Chabasie scratches glass feebly; before the blow-pipe, it melts into a white spongy enamel with little ebullition; it does not gelatinize with acid. According to Vauquelin, it contains — Silex 43.33, Alumine 22.69, Lime 2.24, Soda 9.34, Water 21.

Sp. 21. ANALCIME.

Analcime, *Cubicite*, Werner, and *Cubic Zeolite* of former mineralogists, occurs, like the preceding species, in the cavities of basaltic rocks, either in single crystals or in groups densely and confusedly aggregated. The primitive crystal is a cube with indications of a cleavage parallel to each of the sides; one of the secondary forms is a cube with each solid angle acuminated by three planes set on the lateral planes (see Plate IV. fig. 3.); this variety is called *analcime triepointée*. Another form of the secondary crystal is represented Plate IV. fig. 10. It has twenty-four trapezoidal faces, like the leucite. The crystals of analcime are generally small; but in the British Museum there are some crystals of trapezoidal analcime, more than two inches in diameter. The colours of analcime are greyish-white and grey of various shades; it is transparent or translucent; the surface of the transparent crystals is splendent.

The specific gravity is 2.24, and the hardness sufficient to scratch window-glass. Before the blow-pipe, it melts into a transparent glass, and becomes electric by rubbing.

Sp. 22. PREHNITE.

Prehnite received its name from its discoverer, M. Prehn, the Governor of the Cape of Good Hope. This mineral most commonly occurs in globular or botryoidal concretions in basaltic rocks, which are characterised by their radiated structure and a pale green colour; it also occurs in amorphous masses, which have a promiscuously laminar or granular structure, and are sometimes compact. It also occurs in crystals, either single or in groups. The primitive form is a rhomboidal prism, the obtuse angle of which is 103°; the structure is imperfectly laminar, with a cleavage parallel to the direction of the smaller diagonal of the base; and, according to Haüy, it presents indications of a cleavage parallel to the sides of the rhomboid. (*Tableau Comparatif*, p. 197.) The secondary forms are generally six-sided tables, or flat four-sided prisms, bevelled on the edges. The crystals are commonly adhering, and arranged in groups, and diverging like a fan. The prevailing colour of prehnite is pale-green; but it is sometimes a yellowish-white. The lustre is pearly, that of the crystallized varieties is shining, and of the concretions glistening. The specific gravity is from 2.60 to 2.90. The hardness of some varieties of prehnite is sufficient to scratch felspar. Prehnite melts before the blow-pipe into a whitish frothy glass; it becomes electric by heat, but does not gelatinize with acids. Several varieties of prehnite have been analysed; they contain — Silex from 43 to 48, Alumine 24 to 30, Iron from 2 to 4, Water 1 to 2.

Laminar or foliated prehnite, is composed of minute rhomboidal plates promiscuously aggregated; it has a greenish or yellowish-white colour. When white it nearly resembles one variety of granular lime-stone, with spots of green talc. It was supposed at one time to be a distinct species, and received the name of keupholite.

According to the Count de Bournon, some varieties of jade brought from China, and which are commonly cut into vases and ornaments, are in reality laminar or granular prenhite. Some unpolished specimens of this mineral in the British Museum, in which the structure is distinctly shown, confirm this opinion; they are of a beautiful white colour, passing in some parts into green.

The prehnite which occurs in globular and mamillated concretions, and amorphous, is called sometimes fibrous prehnite; it is this variety which occurs near Dumbarton, and in various basaltic rocks in other parts of Scotland. It was not known as an English mineral until 1816, when the author of the present volume discovered it in a low basaltic rock, which was quarried for the roads at Woodford Bridge, near Berkley, in Gloucestershire. The rock is a brown amygdaloidal wacke, in which the prehnite occurs imbedded in globular concretions of considerable magnitude, mixed with green-earth and calcareous spar. Some of the concretions were six inches in diameter, and composed of smaller globular concretions of prehnite, internally radiated; the colour is sea-green and translucent; it scratches felspar feebly, and melts with ease into a white enamel. Prehnite has since been discovered in the basalt of Staffordshire. Crystallized prehnite is found in veins both in hornblende and granite in France, and in amygdaloid in various parts of Europe. The finest specimens come from the south of Africa. Prehnite is found in veins and nodules in Connecticut and Massachusetts, in the United States.

The distinctive characters of prehnite are its hardness and specific gravity, which are greater than those of mesotype or stilbite; its prevailing colour is green.

SP. 23. HARMOTOME, or CROSS-STONE.

This mineral occurs in small crystals, which are generally broad rectangular four-sided prisms, terminated by four planes set on the lateral edges; sometimes two of these prisms intersect each other in such a manner that the axes coincide, and when viewed in the direction of the axes they form a cross; this crystal is represented Plate IV. fig. 5. The primitive form is a double four-sided pyramid, with square bases, forming an octahedron, which is divisible by cleavages parallel to the lateral edges of the pyramids, and to the base. The faces of the pyramids meet at the base under an angle of 86° 36′.

The colour of harmotome is milk-white or greyish, sometimes inclining to yellow or red; it is translucent or semi-transparent. The lustre is pearly, inclining to vitreous, and is internally glistening. The specific gravity is 2.23. Before the blow-pipe, it melts into colourless glass. It is distinguished in its composition from all other zeolitic minerals by containing barytes. According to Klaproth, its constituent parts are — Silex 49, Alumine 16, Barytes 18, Water 15. Harmotome has been found at Andreasberg in the Hartz, at Kongsberg in Norway, and at Strontian in Scotland. It also occurs in some of the volcanic rocks on Mount Vesuvius.

Sp. 24. APOPHYLITE.

Apophylite, *Fish-Eyestone*, *Ichthyophthalmite*. — This mineral bears a near resemblance to stilbite. The prevailing colour is white, often with a tint of green or red; it is semi-transparent or translucent, and sometimes nearly opaque; it has a splendent lustre, which, in the direction of the principal cleavage, is pearly and irridescent. It occurs in regular crystals, and in small tabular or laminar concretions. The primitive crystal is a right rectangular prism, in which the proportion of the sides of the base to the height, according to Haüy, are as 14 and 18 to 15. The secondary forms are rectangular prisms, variously modified; sometimes all the solid angles are truncated, and sometimes two of the sides are much larger than the rest, forming tables; these often intersect each other. The cleavages are parallel to the sides and base of the prism; but those parallel with the base are the most distinct: it is these surfaces which are splendent, pearly, and irridescent; the cross fracture is conchoidal and vitreous.

The specific gravity is about 2.45. It yields with ease to the knife.

Apophylite occurs, at the Island of Utoe in Sweden, in beds containing magnetic iron-stone, felspar, calcareous-spar, and hornblende; and in the mines of Fahlun, and at Arendal in Norway.

Distinctive Characters of Apophylite. — According to Brongniart, it separates into thin laminæ when rubbed on any hard body. Before the blow-pipe it melts very readily, and phosphoresces during fusion, and even exfoliates in the flame of a candle, or when thrown into acids. It becomes electric by friction. When pulverized it gelatinizes in acids. Though several of these characters are found in other zeolitic minerals, its pearly irridescence and exfoliation in acids, joined with the cleavage, distinguish it from mesotype or stilbite. It is much softer than adularia. The constituent parts of apophylite are — Silex 4, Lime 28, Potash 4, Water 17. Vauquelin.

Sp. 25. LAUMONITE?

Laumonite, was so called from M. Gillet Laumont, a French mineralogist, who first discovered it in the lead-mines of Huelgoet in Britanny; it was for some time regarded as decomposing zeolite. It occurs in small crystals and distinct laminæ. The crystals are oblique four-sided prisms, with all the lateral edges truncated, giving to the prism a sub-cylindrical form. The primitive crystal, according to Haüy, is a rectangular octahedron, with the faces unequally inclined to the summits, forming lateral angles of 121° 24′ and 98° 12′. The cleavage is parallel to the diagonals of the common base of the pyramids which form the octahedron. Thecolours are white, inclining sometimes to yellowish-white or grey ; the lustre is pearly and glistening or shining. When fresh, the specific gravity is 2.20, and it scratches glass ; but it soon effloresces and becomes opaque and tender by exposure to the air. Before the blow-pipe, it melts with ebullition into a white compact pearly enamel ; it dissolves rapidly, and gelatinizes in muriatic acid. Laumonite has been found near Paisley in Scotland, in the Isle of Skye, and in the basalt of the Giant's Causeway in Ireland. The constituent parts are — Silex 40, Alumine 22, Lime 9, Water 17.5, Carbonic Acid 2.5.

Sp. 26. LEUCITE, or AMPHIGENE.*

Sodalite ?

Leucite, formerly called *white garnet*, is a mineral easily recognized : it occurs imbedded in the lava of Vesuvius and in many volcanic rocks in Italy, either in roundish-shaped crystals or in grains. The crystals have twenty-four similar trapezoidal faces, as represented Plate IV. fig. 10. ; this is the only form of the crystal, and it is generally very distinct, but sometimes the angles are rounded. The crystals

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* The name amphigene, implying a double origin, was given to leucite on account of the supposed double form of the primitive crystal.

are found an inch or more in diameter, but more generally about the size of a large pea or smaller. Leucite, in minute grains, forms a component part of many lavas. The most common colour of leucite is a grey or dingy-white, sometimes inclining to red.* It is more or less translucent; the lustre vitreous or resinous, and glistening or shining; the surface of the crystals are generally smooth; their only form is that already described. According to Haüy, the crystal may be divided into two primitive forms, the cube and the rhomboidal dodecahedron; but as the cleavages are indistinct, we ought perhaps to consider the primitive form as yet undetermined. The fracture is commonly undulated. The specific gravity of leucite is about 2.45; its hardness is variable, sometimes only sufficient to scratch window-glass feebly. It is infusible before the blow-pipe, a circumstance very remarkable from the large quantity of potash which it contains; the constituent parts being Silex 54, Alumine 22, Potash 22. Leucite may be distinguished from garnet by its inferior hardness, low degree of specific gravity, and infusibility. Infusibility also distinguishes leucite

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* I have a mass of lava from Vesuvius, in which there are many crystals of leucite nearly of a flesh-red colour; some have part of the lava imbedded in the crystals. These leucites are not very uncommon, and are called by the natives *leucito rosso*.

from analcime, which has sometimes the same crystalline form, but it occurs lining cavities in basalt, whereas leucite is closely imbedded in the mass. It has been doubted whether the crystals of leucite were originally crystallized in lava while it was cooling, or whether they were already formed and afterwards enveloped by it. This latter opinion is entertained by some geologists, but it is at variance with probability, as well as existing appearances. Grains of leucite form a component part of the lava itself, and some of the crystals of leucite contain imbedded particles of lava. Whilst writing the present article, I attempted to try the hardness of a very fine crystal of white leucite, when it divided by the pressure, and discovered a number of acicular crystals of basaltic hornblende, imbedded in the very centre of the leucite. The crystals of hornblende are precisely similar to those in the lava that surrounds the leucite; hence we may infer, that they were all formed at the same time.

SODALITE ? — This mineral has hitherto been found in West Greenland; it seems nearly allied to leucite, but occurs with sahlite, augite, hornblende, and garnet, in a bed about twelve feet thick, situated in mica-slate. It is of a blueish-green colour, and crystallized in rhomboidal dodecahedrons, and also amorphous: it has a two-fold cleavage, a conchoidal fracture, a shining resinous lustre, and is translucent. Sodalite is harder than felspar; the specific gravity is 2.37, and is infusible before the blow-pipe. The constituent parts given by Dr. Thompson are — Silex 38½, Alumine 28½, Soda 25½, Lime 2.70, Muriatic Acid 3, Oxide of Iron 1, Volatile Matter 2.

Sp. 27. MEIONITE.

Meionite, called *Hyacinth blanche* by earlier French mineralogists, occurs in the cavities of volcanic rocks in the vicinity of Vesuvius, either in small aggregated crystals, or in grains. The colour is white inclining to grey; the lustre is vitreous and splendent, or shining. Meionite is semi-transparent or transparent; the crystals are generally four-sided prisms, or four-sided prisms truncated on all the edges, forming eight-sided prisms; they are terminated by four planes set on the lateral edges, forming low four-sided pyramids. The terminal planes form with the sides of the prism angles of 121° 45′. The primitive form is a right rectangular prism with square bases, the length of the sides being to the height nearly as 9 to 4. Meionite has a laminar structure, and a double rectangular cleavage, parallel to the sides of the primitive crystal. The specific gravity is about 2.55; it is scratched by felspar. Before the blow-pipe, it fuses with intumescence into a white porous glass. Mr. Allan, in his "Mineralogical Nomenclature," has given the constituent parts of meionite, as Silex 46, Alumine 49, Lime 2, Iron 1; but as this analysis is the same as that of nepheline given by M. Vauquelin, it probably relates to the latter mineral.

Sp. 28. NEPHELINE, or SOMMITE.

Nepheline, *Sommite,* occurs like meionite in the cavities of volcanic rocks near Vesuvius, either in aggregated crystals or grains; it greatly resembles meionite in colour, lustre, and transparency, being white and semi-transparent, and possessing a splendent or shining lustre, but its crystals are equiangular hexagonal prisms, which is the primitive form, the breadth of the base being to the height nearly as 15 to 7. Sometimes the edges of the secondary prisms are truncated round the base. It has four cleavages, three parallel to the sides of the prism, and one parallel to the base; the cross fracture is conchoidal; it is scratched by felspar. The specific gravity is 2.27. It melts with much greater difficulty than meionite. When exposed to the blowpipe, and when immersed in nitric acid, it becomes cloudy in the interior; hence Haüy gave to this mineral the name from the Greek word *nephele*, denoting a cloud. Its cleavage and inferior hardness distinguish it from glassy felspar and adularia.

Werner has made a distinct species of a mineral commonly found with nepheline, and called it ice-spar, which appears to be nothing more than lamellar or amorphous nepheline.

SP. 29. LAZULITE, or LAPIS-LAZULI.

Azurite?

LAZULITE, or LAPIS-LAZULI, is characterised by its bright azure-blue colour; it is frequently veined with yellow pyrites, and sometimes contains white spots which are regarded as defects in this stone by artists. It is opaque, and in its native state possesses little lustre. The texture is fine-grained or nearly compact. The specific gravity is about 2.93, and the hardness about equal to felspar.

Lazulite occurs massive, associated with garnets, felspar, and mica, in veins that traverse granite, in which rock it is said to be sometimes disseminated. It has in a few instances been found crystallized in rhomboidal dodecahedrons. Lazulite is deprived of its colour rapidly by nitric acid; before the blow-pipe, it melts into a blackish mass, which at a high temperature forms a white enamel. The constituent parts, according to Klaproth, are — Silex 46, Alumine 14.50, Carbonate of Lime 28, Sulphate of Lime 6, Oxide of Iron 3, Water 2.

The finest lazulite comes from China and Bucharia; it is also found, but of an inferior kind, in Persia, Armenia, and Siberia, near the lake of Baikal.

This mineral is employed in jewellery, but is most valued as yielding the blue colour, called *ultre marine.* This beautiful pigment is obtained by a process that consists principally of calcination, trituration, and subsequent washing, which carries off the colouring matter into other vessels, where it is deposited. Brongniart Mineralogie, tom. ii. 369.

Azurite, sometimes called *false lazulite.*—This mineral is of little importance; it has been found in Stiria, the Tyrol, and in Salzburg, imbedded in small pieces, in quartz that occurs in the fissures of clay-slate. The colours are indigo-blue or smalt-blue, and the lustre vitreous. It is stated by Mr. Jameson to occur crystallized in oblique four-sided prisms, flatly acuminated on the extremities with four planes, set on the lateral edges. The structure is imperfectly laminar, with joints parallel to the sides of a rhomboidal prism; it is infusible, but with borax forms a yellow globule of glass. The constituent parts are—Alumine 66, Magnesia 18, Silex 10, Lime 2, Oxide of Iron 2.5.

Sp. 30. HAÜYNE, or LATIALITE.

This mineral, originally found in basaltic rocks near Frascati and Albano, and since discovered in the volcanic ejections from Vesuvius, and in the basaltic lava of Andernach, was called *latialite* by Haüy, but by some mineralogists has received the name of *Haüyne*, after that eminent crystallographer; an honour to which it is little entitled, either from its beauty or importance.

It occurs amorphous and disseminated in the above-mentioned rocks, either in grains or crystallized in rhomboidal dodecahedrons like garnets. The colours are sky-blue or prussian-blue; the lustre vitreous. The specific gravity is 3.20; the hardness equal to felspar. Before the blow-pipe it is infusible; it gelatinizes with acids, emitting the odour of sulphuretted hydrogen. The constituent parts of Haüyne, as given by Vauquelin, are — Silex 30, Alumine 15, Sulphate of Lime 20.5, Lime 5, Potash 11, Iron 1, Sulphuretted Hydrogen 3. Loss 14.95, supposed to be Water.

SP. 31. PARANTHINE, SCAPOLITE, or WERNERITE.

Gabronite.

Great confusion prevails in many of the descriptions of this mineral; it occurs but in few situations, and possesses neither beauty nor any peculiar properties to entitle it to much notice; but as the varieties differ much in colour and lustre, they have sometimes been described as distinct species, and one of these varieties has been honoured by affixing to it the name of the celebrated mineralogist of Freyburg. Paranthine, or scapolite, occurs both crystallized and massive; it is very subject to decomposition, and, to this cause the diversity of colour and lustre, which it frequently presents, may be owing. The colours generally incline to grey or green, or to greyish or greenish-white, but are sometimes red; the colours are, however, too numerous to serve as a distinctive character, and their enumeration would be more likely to perplex than to aid the student. *

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* Mr. Jameson divides scapolite into three sub-species, radiated, foliated, and compact; and the latter he divides into two kinds. Foliated scapolite he describes as presenting the following colours: "grey and green, white, blue, and brown; from greenish-grey it passes on one side into greenish-white, greyish-white, and snow-white. On the other into mountain-green, which passes into a celandine-

Crystallized Paranthine. — The structure is laminar, with cleavages parallel to the primitive form of the crystals, which, according to Haüy, is a low rectangular prism, the side of the base being to the height of the prisms nearly as 5 to 3. The common forms are four or eight-sided prisms, terminated by four or eight planes. The crystals vary in size, from acicular to the thickness of a small reed, and are sometimes long; hence Werner gave this mineral the name of scapolite, from the Greek word signifying a rod. There is a fine cluster of long crystals among the specimens in the British Museum.

The surface of the crystals are shining internally; the lustre is vitreous or resinous, inclining to pearly.

Compact or amorphous paranthine, or scapolite, is greenish or greyish-white, or brick-red, the lustre dull, the fracture uneven or splintery, with indications of a double cleavage. The specific gravity of paranthine is about 3.60. Owing to its speedy decomposition, the hardness is variable. When sound it scratches

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green, verdigris-green, sky-blue, smalt-blue, indigo-blue, dark-blue; on the other into pistachio-green, asparagus-green, olive-green, oil-green, liver-brown, reddish-brown, yellowish-brown, and muddy honey-yellow. The colours are sometimes pure, generally pale and muddy, and sometimes two colours occur in the same specimen," &c. Jameson's Mineralogy, vol. i. p. 388.

glass feebly; its constituent parts are given as under:

Silex -	40	51	45
Alumine -	34	33	33
Lime -	16	10.45	17.6
Oxide of Iron	9.50	4.50	1
Potash and Soda	——	——	1.5

Paranthine is fusible before the blow-pipe, melting with intumescence into a white enamel. It has been found at Arendal in Norway; and one of the varieties occurs in white-stone, or compact felspar in the Saxon Erzegebirge.

GABRONITE. — A mineral called gabronite has been described as a variety of felspar. I am informed by Mr. Heuland, that it is a crystallized variety of paranthine. According to the analysis of Johns, it contains—Silex 54, Alumine 24, Magnesia 1.5, Iron 1.25, Potash and Soda 17.25. The constituent parts in this analysis are nearly the same as those of elaolite or fetstein; its other characters agree nearly with paranthine.

SP. 32. ELAOLITE, or FETSTEIN.

FETSTEIN, *Werner;* COMPACT SCAPOLITE, *Hausman.* — This mineral is classed by some mineralogists with wernerite; but is supposed by others to be more nearly allied to felspar. It is found massive in Norway. Elaolite has a shining resinous lustre; it is translucent, and the blue variety has a slight play of colour, like that of Labrador felspar.

The prevailing colours are dark-blue or grey; it is sometimes flesh-red and brown. The specific gravity is from 2.58 to 2.61. It is softer than felspar. It gelatinizes in acids when powdered, and is fusible before the blow-pipe. The constituent parts, according to Vauquelin, are— Silex 44, Alumine 34, Lime 0.12, Potash and Soda 16.50, Oxide of Iron 4. This mineral is separated from wernerite by Haüy, on account of the difference of the cleavages, which are parallel to all the faces of a right rhomboidal prism; it cleaves also in the direction of the smaller diagonal of the base.

LYTHRODES.—The mineral called *Lythrodes* is a brownish-red variety of elaolite; when fresh broken, it appears as if spotted with coagulated blood.

SP. 33. MICA.

Lepidolite?

MICA is characterised by the facility with which it divides into extremely thin, smooth, and shining plates or laminæ, that are transparent, flexible, and highly elastic. This last property is possessed by no other mineral. Mica, though it rarely exists in large masses, is more extensively distributed than almost any other mineral substance. In the form of shining scales or laminæ, it exists as a constituent part of granite, and of many of the schistose rocks covering granite. It occurs in small laminæ in a variety of sand-stones, and in the sands of rivers. Mica also abounds in various volcanic rocks. Quartz, felspar, and mica, are sometimes collected in large masses in the veins that traverse granite, instead of being more equally distributed, as in the granite rock itself: in these veins, plates or tabular masses of mica of considerable size are found, particularly in Siberia, near the banks of the rivers that run into the Lena. From thence mica is obtained as an article of commerce called Muscovy-glass, being employed in place of window-glass, as it may be divided into plates of any required degree of thickness.

In the veins that traverse the granite near Aberdeen, thick plates of mica several inches in length and breadth, are frequent. When the plates of mica are so thick as to reflect coloured light, the colours are grey, brown, silver-white, yellow, or black. The plates of mica when thick are sometimes only translucent. The surface has always a shining or splendent lustre, approaching to metallic. According to Haüy, mica is susceptible of a division into laminæ, not more than about one-millionth part of an inch in thickness, which reflect a beautiful blue colour. Mica sometimes occurs in regular crystals, which are rhomboidal four-sided prisms or tables, six-sided prisms or tables, and sometimes oblique six-sided pyramids. The crystals are generally small, and they are sometimes divergingly aggregated. The terminal planes are smooth.

The primitive form of mica, according to Haüy, is a right rhomboidal prism with alternate angles of 120° and 60°. * The cleavage of mica is very distinct in the direction of the terminal planes, but difficult to be effected in the direction of the lateral planes of the prism. Sometimes the laminæ of mica are curved or undulated, or sometimes they appear like broad parallel or diverging fibres, or are marked with plumose striæ. The specific gravity of mica is from 2.60 to 2.80. It can be easily scratched with a knife on the surface of the plates, but the edges are sufficiently hard to scratch glass or even quartz. Mica has a smooth but not an unctuous feel, like talc. Before the blow-pipe, it is fusible into a grey enamel.

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* According to Bournon, the prism is oblique, the terminal planes being inclined to the axis of the prism, making with the lateral edges, formed by the obtuse angles of the prism, angles of 98° and 102°. The height of the prism is equal to the length of the terminal planes. *Catalogue Minéralogeque*, p. 115.

The constituent parts are given as under: by

	Silex.	Alumine.	Iron.	Potash.	Lime.	Mag.
Vauquelin -	50	35	7	——	1.33	1.33
Klaproth -	47	20	15.5 Mang. 1.75	14.5	——	——
Ditto - -	48	34.25	4.5	8.75	——	0.50
Black Mica	42.5	11.5	22	10.00	——	9.00

Mica communicates negative electricity to sealing-wax when rubbed upon it. This property and its elasticity are sufficient to distinguish it from talc. It appears, however, in some instances, to pass into the latter mineral, particularly in some kinds of mica-slate. From the great quantity of iron in some varieties of mica, they form a black or deep-brown earth when they decompose, which may be observed at the Malvern Hills in Worcestershire, and in the decomposing mica in granite veins in other situations. It is owing to the iron in mica, that so few granite rocks will form a white material for porcelain, when ground and exposed to heat.

LEPIDOLITE, or SCALE-STONE, as the name implies, is composed of scales or minute laminæ; these are aggregated and closely adhering, forming grains or granular masses, imbedded in rocks of granite, lime-stone, or serpentine. Sometimes the laminæ are hexagonal plates. Haüy regards lepidolite as a variety of mica. The colour is a lilac-purple, inclining to red or grey; but the separate scales are white and pearly, and have a shining lustre. The specific gravity is from 2.60 to 2.81. It may be cut with a knife, and is sometimes worked into snuff-boxes, which have a pleasing colour, but the lustre is generally dull and oily. Before the blow-pipe, lepidolite melts into a white or yellow globule, according as it is more or less pure. The constituent parts are—Silex 54, Alumine 20, Potash 18, Fluate of Lime 4, Manganese 3, Iron 1. Vauquelin. —According to Klaproth, Silex 58, Alumine 38, Potash 4, Manganese and Iron 0.75, Water and Loss 2.50.

Lepidolite was first found near Rosena in Moravia, and has since been discovered in various parts of Europe, and recently in granular limestone in Scotland near Dalmelly, and at the head of Loch Fine, and near Ballachuish. I have a specimen of serpentine from Portsoy, which has lepidolite closely adhering, and some scales of the lepidolite are also imbedded in the serpentine.

Sp. 34. PINITE.

This mineral is rather scarce, and is of little importance either to the geologist or mineralogist. It generally occurs in granite in imbedded crystals, which are hexahedral prisms, and sometimes in thick laminæ or plates. It is opaque, and the colours are blackish-green, brown, or red. It has a more or less distinct cleavage, parallel with the base of the prism; the cross fracture is fine-grained and uneven. The specific gravity is about 2.91. It yields with ease to the knife, and is sectile. The constituent parts, according to Klaproth, are — Silex 29.50, Alumine 63.75, Oxide of Iron 6.75. According to Vauquelin, it contains — Silex 46, Alumine 42, Oxide of Iron 2.5, Loss by Calcination 7. Pinite is found in Saxony and Dauphiny, and at St. Michael's Mount, near Penzance. It has sometimes been confounded with mica.

Sp. 35. TALC.

This mineral often resembles mica in its lustre and laminar structure; it is, however, of much more rare occurrence, particularly in its purest state. It sometimes occupies the place of mica in granitic rocks; but is more frequent in granular lime-stone and dolomite. In a less pure state it forms schistose beds of considerable magnitude in primitive mountains, which frequently pass into a chlorite slate; indeed, there appears to be little difference between these minerals, and they are classed by Haüy in the same species. The lamellar masses of chlorite slate are composed of grains; but those of talcous slate are composed of laminæ or scales.

Talc is characterised by its soft and peculiarly unctuous feel; its prevailing colours are silver-white or green, and the lustre is pearly and splendent or shining. Talc occurs massive and disseminated, and more rarely, crystallized in minute regular six-sided tables. The primitive form, according to Haüy, is a rhomboidal prism, with angles of 120° and 60°.

The structure of talc is finely and curvedly laminar; the laminæ are translucent, flexible, and easily separated. They are not elastic like those of mica, with which they are sometimes confounded, and to which they bear a great resemblance; they are further distinguished by their softness and unctuosity. Talc yields to the nail, and is sectile; it fuses with great difficulty into a small globule of white enamel.

The specific gravity is about 2.80.

The constituent parts are — Silex 62, Magnesia 27, Alumine 1.50, Oxide of Iron 3.50, Water 6. Vauquelin.

An analysis of Klaproth gave 30 parts of magnesia, and 2.75 potash.

Indurated Talc, *Talc Endurie* and *French Chalk*, is harder and has less lustre than the preceding variety. The colours incline to greenish-grey, the lustre is pearly and glistening or shining, and it is translucent in thin pieces; it has an imperfect or curvedly lamellar structure, approaching to schistose; it is sometimes fibrous or radiated. This variety of talc is sectile, and is employed for tracing lines by carpenters and glaziers. Indurated talc forms beds in primary mountains in various alpine districts, particularly in Switzerland. It is found also in Perthshire and Bamfshire.

Talc, in a fibrous state, appears to pass into asbestus, in a more indurated state into potstone, and in a soft earthy state into steatite.

Talc, beside being cut into marking pencils, is used for taking stains from silks, and performs the more important service of restoring to the pale cheek of disease or age, the roseate bloom of health and youth; for when mixed with carmine and powdered, it forms the basis of the well-known cosmetic, *rouge*.

Sp. 36. CHLORITE.

Earthy-Chlorite.
Common-Chlorite.
Chlorite-Slate.
Foliated-Chlorite.
Silvery-Chlorite.
Green-Earth.

Chlorite, *Talc Chlorite*, Haüy, so called from the Greek word *chloros*, green, which is the prevailing colour of this mineral, varying from dark-green to light greyish-green; the colours are generally rather dull; it is opaque, and the lustre glimmering, inclining to pearly. Chlorite occurs in minute scales or grains, which when viewed by a microscope, are hexagonal prisms; they are frequently aggregated in amorphous masses, but the grains are easily separable, and may be reduced to a soft and unctuous powder, which has a light greyish-green colour.

Chlorite, either in detached or aggregated grains, is often disseminated in various rocks and veins, and is sometimes imbedded within crystals of quartz and adularia. Schistose beds almost entirely composed of chlorite, frequently alternate with beds of clay-slate and hornblende-slate, forming a variety of slate, called chlorite-slate by geologists. Chlorite is infusible before the blow-pipe; all its varieties may be scraped with a knife; the specific gravity varies from 2.82 to 2.90.

The analyses of chlorite given by different chemists vary considerably. One of common chlorite, by Vauquelin, gives — Silex 56, Alumine 15.5, Lime 3, Iron 4, Potash 8, Water 6. Another variety gave — Silex 56, Alumine 18, Lime 3, Iron 4, Potash 8, Water 6. In a variety of earthy chlorite analysed by Hopfner, we find Magnesia 43; and in one variety by Vauquelin, iron 43.3. Some mineralogists divide chlorite into the following varieties:

EARTHY-CHLORITE, *Talc Chlorite terreux*, is the chlorite that occurs in friable and loosely adhering grains; it is either imbedded in other minerals or incrusting them.

COMMON-CHLORITE is essentially the same as earthy-chlorite, but the grains of which it is composed are more firmly adhering. It occurs disseminated in granite and other rocks and in veins. This variety is common in the isles of Arran and Bute, and in many parts of Scotland, and also in Cornwall, where it is found in veins.

CHLORITE-SLATE, *Talc Chlorite fissele*, Haüy, occurs in beds which have a slaty structure. It is found remarkably well characterised in the grounds of the Duke of Argyle, near Inverary Castle, and also in various parts of Scotland.

FOLIATED-CHLORITE. — In this variety, the hexagonal scales of chlorite are larger and distinctly visible, forming small six-sided tables or prisms, which have a cleavage parallel to the base. The laminæ are generally curved; the lustre is shining and resinous; it is translucent on the edges. The crystals are often grouped, forming cylindrical or conical masses. This variety is rare; it occurs, according to Mr.

Jameson, in a micaceous rock in the island of Jura, one of the Hebrides. As this variety is more perfectly crystalline than the others, its analysis should probably be taken as representing that of the species; it is given by Lampadius as follows: — Silex 35, Alumine 18, Magnesia 29, Iron 9.70, Water 2.70.

White Silvery Chlorite consists of pearly-white or greenish-white scales, sometimes forming masses in the cavities of primary rocks. The scales are feebly adhering, and may be separated with the finger. According to Vauquelin, it contains — Silex 50, Alumine 26, Iron 17.5, Potash 5, Lime 1.5.

Green-Earth is regarded by some mineralogists as a distinct species, but by others more properly as a variety of chlorite. It is generally of a lively green colour. It occurs principally in small globular masses in basaltic amygdaloid, or lining cavities or veins in the same kind of rock, or coating other minerals. Its fracture is fine-grained earthy, and is dull. Green-earth is soft, unctuous to the touch, and sometimes adhering to the tongue. It is converted into a black slagg before the blow-pipe. It contains, according to Klaproth — Silex 53, Oxide of Iron 28, Magnesia 2, Potash 10, Water 6. Green-earth is used as a green water-colour in painting, and when calcined it affords a durable brown.

SP. 37. ASBESTUS.

Amianthus.	*Ligniform-Asbestus.*
Common-Asbestus.	*Rock-Cork.*

ASBESTUS. — This mineral is distinguished by its fibrous structure; in some of the varieties, the fibres are so delicately fine and so flexible, as to resemble flax or silk; hence they were woven by the ancients into cloth, which, being incombustible, was sometimes made use of to enfold the bodies of the dead, and preserve their ashes before they were placed on the funeral-pile. It is doubted by Bournon and other distinguished mineralogists, whether asbestus be a distinct mineral species, or only a fibrous form of amphibole (hornblende), talc, or of some other species; for many minerals pass from a fibrous to a capillary form, and thus approach to the nature of asbestus. The analysis of asbestus agrees nearly with that of some varieties of amphibole, and the transition from fibrous tremolite (*amphibole grammatite*) to common asbestus is not greater, than may often be observed in varieties of the same species. According to the observations of Haüy and Bournon, the delicate fibres of asbestus, when highly magnified by the microscope, appear to be rhomboidal prisms.

AMIANTHUS, or FLEXIBLE ASBESTUS, is frequently found filling veins in serpentine and amorphous; it is composed of delicate fibres, which are arranged parallel to each other, and easily separated; they have the lustre and soft feel of silk, and are flexible and somewhat elastic. The prevailing colour is greenish-white. It is soft and sectile. The specific gravity varies considerably, but is generally under 2.30. Its constituent parts are — Silex 59, Magnesia 25, Alumine 3, Lime 9.05, Oxide of Iron 2.25. Single filaments are melted by the blow-pipe into an enamel; larger pieces melt with great difficulty.

Amianthus occurs in veins in the serpentine of Anglesea, and in Cornwall; it is found at Glenelg in Scotland, and in Savoy, Corsica, and the Pyrenees. In the manufacture of amianthus into cloth, the filaments were mixed with those of flax, and formed into threads and woven; a considerable quantity of oil was used in the process. The cloth was rendered pure by fire, and the flax was burned out. A method of manufacturing it into cloth, without any admixture of flax, has recently been discovered; the process consists in softening the amianthus in water, heating it, and then rubbing it, to separate the filaments, and combing it with a fine steel comb.

Common-Asbestus is more coarsely fibrous than amianthus; the fibres possess little flexibility, and are so firmly adhering, that it breaks into splintery fragments, which are translucent on the edges. The fibres are frequently rather curved, and are always parallel. The colours are leek-green, olive-green, or greenish-grey; the lustre is glistening, and inclining to pearly. It is soft, and feels rather unctuous. The specific gravity varies from 2.00 to 2.50. It melts with greater ease than amianthus before the blowpipe, and forms a black glass.

Common-asbestus most frequently occurs in serpentine; it is found near Lisekard in Cornwall, and also in the serpentine of the Lizard, and in Anglesea.

Ligniform-Asbestus, or Wood-Asbestus, differs from common-asbestus in its colour, which is a wood-brown; it occurs in curved lamellæ, or plates, which have a promiscuously fibrous structure resembling wood; the fibres are slightly flexible and elastic; it is tough, sectile, and feels meagre to the touch. The specific gravity is about 2.05. It occurs principally in the Tyrol.

Some varieties of asbestus have the fibres so closely adhering as to be called compact. The constituent parts of the different varieties of asbestus contain — Silex 60 to 64, Alumine 2 to 3, Magnesia 17 to 25, Lime 6 to 13, Iron 1 to 6.

Rock-Cork, *Asbeste Suberiform*, Brongniart.— This mineral nearly resembles cork, and is distinguished by its great lightness, as it will swim on water; the specific gravity varying from 0.70 to 0.98. It is promiscuously fibrous, and hence contains a number of minute pores, to which its lightness is to be ascribed. Its structure appears granular, unless it be minutely examined. Rock-cork has generally a yellowish-white colour, or inclining to grey, and is destitute of lustre. It occurs in plates of various degrees of thickness, which are slightly flexible and elastic ; the thin plates are sometimes called rock-leather. It yields to the nail, but breaks with great difficulty. Before the blow-pipe, it requires a considerable time to melt, and then forms a white glass. The constituent parts are — Silex 56, Magnesia 26, Alumine 2, Lime 12.7, Oxide of Iron 3. Bergman.

It occurs in veins in serpentine at Portsoy, and in the fissures of trap-rocks in Mearnshire.

Sp. 38. GARNET.

Precious-Garnet.
Pyrope.
Common-Garnet.
Colophonite.
Melanite.
Grossular.
Allochroite.
Cinnamon-Stone.

Garnet most frequently occurs in roundish-shaped crystals, which are either rhomboidal dodecahedrons, or some modification of that form (Plate IV. figs. 9 and 10.) ; sometimes the surface of the planes are convex, arising from a confused crystallization. Garnet also is found in grains and amorphous masses. The crystals are commonly the size of a pea or less, but sometimes they are several inches in diameter, or the size of a melon. The crystals of garnet are most commonly imbedded in the rocks denominated *primary*, particularly in mica-slate; they also occur in cavities and in veins, and in some volcanic rocks. The prevailing colours of garnet are red, brownish-red, and more rarely brownish-green. The crystals are translucent or transparent, according as the colour is more or less intense; some varieties are nearly opaque; the lustre is vitreous or resinous, of various degrees of intensity.

The specific gravity varies from 3.75 to 4.20; the hardness is also variable, but is always greater than that of quartz. The structure and cleavage are only distinctly laminar in some of the crystals. The fracture is uneven, and small conchoidal. All the varieties of garnet are fusible into a black slagg or enamel; they are also magnetic, but in some varieties this property is feeble. The essential component parts of garnet appear to be Silex, Alumine, Lime, and Iron; but the proportions differ greatly in some of the varieties of this mineral.

The rhomboidal dodecahedron is the primitive form; the plane angles of the faces are 109½° and 70½°, and the faces incline to each other at angles of 120°. Some of the faces are frequently larger than the rest; according to Haüy, the integrant molecule is a tetrahedron, and the decrements which form the secondary crystals, take place by ranges of subtractive molecules, which are obtuse rhomboids.* There are four secondary forms of the garnet, one with twenty-four faces (*Grenat trapezoidal*), Plate IV. fig. 10.; one with thirty-six faces, in which all the edges of the rhomboid are truncated (*Grenat emarginé*); one with ninety-four faces (*Grenat triémarginé*); and one with sixty faces (*Grenat uniternaire*).

These different forms, and the principal varieties, are arranged in the British Museum, under the head of Grenatine Substances, together with staurolite and vesuvian.

The constituent parts of the several varieties of garnet are given as under:

	Silex.	Alumine.	Lime.	Mag.	Iron.	Mang.	
Precious-Garnet -	35.75	27.25	——	—	36	0.25.	Klaproth.
	36	22	3	—	11	——	Vauquelin.
Cinnamon-Stone -	38.8	21	31.25	—	6.5	——	Klaproth.
Pyrope -	40	28.5	3.5	10	16.5	0.25.	Klaproth.
Melanite -	35.5	6	32.5	—	24.25	0.4.	
Common Garnet	52	20	7.7	—	17	Loss 3.3.	Vauquelin.
	44	8.5	33.5	—	12	——	
Amorphous Garnet -	38	20	31	—	10	——	
Allochroite	37	5	30	—	18.5	Mang. 6.25.	Rose.

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* If the rhomboidal dodecahedron be divided by sections passing through its centre, and coincident with each of the edges, and also crossing the shorter diagonal of each face, it will form twenty-four similar tetrahedrons. These are the form of the integrant molecule. The subtractive rhomboidal molecules are each composed of six similar formed molecules. See *Traité de Minéralogie*, tom. ii. p. 546. By

The following are the principal varieties of garnet:

Noble or Precious Garnet, *Grenat Syrien,* and *Alamandine,* most commonly occurs in crystals, and sometimes in grains, and also in laminar masses, of which there is a fine specimen in the British Museum. The faces of the crystals have commonly the trapezoidal form (Plate IV. fig. 10.), or the rhomboid, with the edges truncated. The prevailing colours are violet-red, crimson, and cherry-red; sometimes the colours are unequal and impure. Precious garnet is transparent or translucent. Its specific gravity exceeds 4, and the hardness is greater than that of quartz.

Precious garnet received the name of *Syrian garnet,* from Syrian in Pegu; it is sometimes called *Bohemian garnet.* It occurs in various parts of the continent of Europe, and in Scotland, and in almost every alpine country that has yet been examined. It is much employed in jewellery.

Pyrope appears to differ little from precious garnet, but it occurs in small rounded pieces or grains, and is often imbedded in serpentine. The red colours of pyrope generally appear tinged with yellow when held between the eye

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marking a rhomboidal dodecahedron across the short diagonals and along the edges, or by cutting a model in those directions, the structure will be easily understood.

and the light. The specific gravity is from 3.71 to 3.94.

Common-Garnet occurs crystallized and amorphous; the colours incline to reddish-brown or reddish-green; it is translucent, and sometimes nearly opaque; the lustre is vitreous and glistening. Amorphous garnet has sometimes a laminar and sometimes a granular structure; the fracture is imperfect conchoidal, or fine-grained uneven. Masses of common garnet of considerable size are sometimes formed by the aggregation of imperfect crystals. Amorphous garnet occurs near St. Just, in Cornwall, with axinite. The localities of common garnet are too numerous to require a description.

Colophonite is a variety of garnet, distinguished by its resinous lustre; its colours are orange-yellow or reddish-brown. It has been found in Norway.

Melanite, *Grenat noire*, Haüy.—This variety occurs in volcanic rocks near Vesuvius, and has also been found in other situations; the colour is velvet-black; the lustre shining and splendent; the form of the crystal is the garnet dodecahedron.

Grossular occurs crystallized, and is distinguished by its yellowish-green colour; it has been named from the supposed resemblance of the crystals to a gooseberry; they are of the same forms as the other varieties of the garnet, and are translucent. The faces of the crystals of grossular are smooth. The specific gravity varies from 3.35 to 3.72. It is found imbedded in greenish clay-stone near Wilui, in Siberia.

Aplome differs from common garnet in the direction of the striæ on the faces of the crystal, which are parallel to the short diagonal of the rhombic face; hence it is supposed to have the cube for its primitive form. The specific gravity is 3.44. According to Langier, it contains — Silex 40, Alumine 20, Lime 14.5, Oxide of Iron 14.5, Oxide of Manganese 2.

Allochroite. — This mineral has been found massive at an iron-mine near Dramen, in Norway, accompanied by brown garnets sometimes intimately united with it: it appears to differ from amorphous garnet principally in the colour, which is yellowish, greenish, or brownish-grey; its lustre is glistening and vitreo-resinous, and it is nearly opaque.

Cinnamon-Stone, *Essonite*, Haüy, *Kanel-stein*, Werner. — This mineral possesses all the essential properties of garnet, but it rarely occurs crystallized. Mr. Lowry informs me he has seen one regular crystal of cinnamon-stone, sent by Dr. John Davy, from Ceylon; it was a garnet-shaped rhomboidal dodecahedron. The common form in which the cinnamon-stone is found in Ceylon, is in small rounded pieces or grains in the sand of rivers.

Cinnamon-stone is cut as a precious stone, and sold under the name of hyacinth.

The principal colours are orange-red. In some varieties, the refracted colours appear yellow when held near to the eye. It is translucent or transparent; and, when pure and free from flaws, is highly valued in jewellery. Cinnamon-stone is rather softer than some varieties of garnet; its specific gravity is 3.60 to 3.64. Though cinnamon-stone contains less oxide of iron than precious garnet or pyrope, yet, like all the varieties of garnet, it is magnetic, though in a slight degree.

CHARACTERS OF GARNET.

Specific Gravity, always nearly equal to or above 3½.

Hardness, greater than that of quartz.

Fusible into a black enamel or slagg.

Magnetic — affects the magnetic needle more or less sensibly.*

Form and Structure. — Crystallized in rhomboidal dodecahedrons, or in different modifications of that form, which is the primitive form — indistinctly laminar, parallel to the faces of the dodecahedron — sometimes amorphous.

Affections of Light. — Colours red and various; refracts single.

Distinctive Character of Garnet. — From leucite it is distinguished by its greater hardness and specific

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* The means of rendering this property sensible will be described in a note on magnetism.

gravity; the latter is infusible. The form of the crystal distinguishes garnet from zircon-hyacinth; the planes of the dodecahedron in garnet, meet at angles of 120°. Zircon-hyacinth is infusible and doubly refractive; it has greater specific gravity than garnet. Vesuvian or idocrase is softer, and easily scratched by garnet. Red sapphire, or the oriental ruby, and the spinel ruby, when cut and polished, have a more lively colour than the garnet; when uncut, they may be distinguished by their superior hardness; and lastly, garnet feebly affects the magnetic needle, which none of the other precious stones will do except peridot, which cannot be confounded with garnet.

Sp. 39. VESUVIAN, *Idocrase*.

Vesuvian. — This mineral was so called from being found in the vicinity of Vesuvius. It is crystallized and amorphous; the colours are reddish-brown and brownish-green, and sometimes hyacinth-red. It is translucent or transparent, and the planes of the crystals have a splendent lustre; the fracture is uneven, and the lustre resinous and shining. The specific gravity varies from 3.08 to 3.44. It scratches glass feebly, but is scratched by garnet. Before the blow-pipe, it melts into a yellowish and faintly translucent glass. The constituent parts of a specimen from Vesuvius, as given by Klaproth, are — Silex 33.5, Alumine 22.25, Lime 33, Oxide of Iron 7.5, Oxide of Manganese 0.25. From Kamschatka — Silex 42, Alumine 16.25, Lime 34, Oxide of Iron

5.5. Vesuvian has a feeble double refraction; it acquires electricity by rubbing.

The primitive crystal of Vesuvian is nearly that of a cube, being a right prism with square bases; the sides of the base are to the height nearly as 15 to 14. It is divisible by cleavages parallel to the sides of the prism, and to the diagonals of the base. The most common form of the crystal is an eight-sided prism; the lateral planes form angles of 135°; it is terminated by four planes. Sometimes the summits are acuminated, as represented Plate IV. fig. 8. The edges are often bevelled, producing a greater number of planes.

It is generally stated, that the vesuvian from the vicinity of Naples, is found in unaltered ejected rocks. In a number of specimens sent me last year from that vicinity, collected on Mount Somma and the Fosso-Grando, the vesuvian is intermixed with the substance, or it lines the vesicular cavities of rocks, which appear evidently to have undergone the action of fire; it is accompanied by nepheline, mica, and garnets. Vesuvian has been found in Piedmont and at Mount St. Gothard; also in Spain, and, according to Dr. Fitton, in Ireland.

Vesuvian is sometimes employed in jewellery; it is called *Gemme de Vesuve*, volcanic crysolite, and hyacinth of Vesuvius.

Sp. 40. AXINITE, or THUMMERSTONE,

Occurs crystallized and in lamellar masses; the common form of the crystal is an extremely flat and oblique rhomboidal prism; the acute edges are so thinly wedge-shaped, as to present a resemblance to the edge of an axe. This character is what first arrests the attention. The colours are brownish-violet, or reddish-brown or grey, or inclining to green. The external lustre is generally splendent; internally it is glistening or shining, and is vitreous: it varies from transparent, to feebly translucent. The specific gravity is about 3.20; the hardness is equal to that of common felspar.

Before the blow-pipe, it melts with intumescence into a dark-green glass. The constituent parts, as given by Klaproth and Vauquelin, vary. — Silex from 52 to 44, Alumine 25 to 18, Lime 9 to 19, Oxide of Iron 8.63 to 14, Oxide of Manganese 1 to 4.

The primitive form of the crystal is a rhomboidal prism (Plate IV. fig. 6.); the bases are oblique-angled parallelograms, with angles of 78½° and 101½°, and the proportion of the sides B C to the edge H, is nearly as 5 and 4 to 10.

One of the secondary forms is represented Plate IV. fig. 7., in which the edges of the oblique prism are truncated. The crystals of axinite, which are differently terminated at each extremity, are often electric by heat; this property is most common in the violet-coloured varieties. The truncating planes of the crystals are smooth, the faces of the primitive form are striated. The crystals are generally aggregated in groups, and often intersect each other. Amorphous and crystallized axinite, is found a little north of the Botallock-mine, near St. Just, in Cornwall, associated with garnet. It was originally discovered at Thum in Saxony, and thence called thummerstone. The finest specimens are from Dauphiny.

This mineral seems nearly allied to garnet, from which it may be distinguished by its crystallization, and inferior hardness.

Sp. 41. IOLITE, or DICHROITE.

Sapphir d'Eau.

Iolite, so called at first from its purple colour, was afterwards named *Dichroite*, implying two colours, as the transmitted light in one direction is a deep violet, in another a yellowish-brown. It occurs amorphous and crystallized, and is imbedded in small masses of felspar or gneiss, which occur in volcanic breccia or tufa, near Cappe de Gatte, in Spain. Iolite has been found at Baudemnais in Bavaria, and at Arendal in Norway. Iolite is translucent or nearly opaque; its fracture is conchoidal, passing into uneven, and the lustre is shining and vitreous. The crystals of iolite are six-sided prisms, which is the primitive form*; sometimes the prisms are truncated on all the edges. The cleavage is parallel to the axis of the prism, and at right angles to the sides of the base, forming triangular prisms, which, according to Haüy, is the form of the integrant molecule. Iolite scratches quartz feebly; it melts with great difficulty before the blow-pipe, into a pale greenish enamel.

Sapphir d'Eau. — A translucent variety of iolite from India, is so called by the French jewellers; the specific gravity is 2.70; it possesses a slight degree of double refraction, and becomes electric by rubbing. The constituent parts of sapphir d'eau and iolite are,

	Silex.	Alumine.	Lime.	Magn.	Iron.	Potash.
Iolite -	42.6	34.1	1.7	5.8	15	—
Sapphir d'eau	43.6	37.1	3.1	9.7	4.5	1

Sp. 42. CHRYSOLITE, or PERIDOT.

Olivine.

Chrysolite is one of the softest of the precious stones, being scarcely so hard as felspar;

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* The violet colour is seen when the rays pass in the direction of the axis of the prism, the yellowish-brown when the rays pass through the sides.

its specific gravity is about 3.40; the colour is a light greenish-yellow, sometimes inclining to brown; it is transparent, and doubly refractive in a high degree. Chrysolite is found imbedded in volcanic rocks, and in basalt; in the latter, it generally occurs in grains or in rounded pieces, and is called *olivine*. In the lava of Vesuvius, it occurs in grains and crystallized, but the finest crystals are brought from the shores of the Red Sea.

The primitive form of the crystal is a right four-sided prism, with rectangular bases; the proportions of the sides of the base to the height, are as 11 and 25, to 14. It cleaves in the direction of the lateral planes of the prism, and has also a less distinct cleavage, parallel to the base. The secondary crystals, of which Haüy has described six varieties, have either eight, ten, or twelve sides, and are terminated by wedge-shaped or by pyramidal extremities; one of the forms is represented Plate IV. fig. 20.

In some of the secondary crystals, the faces are multiplied by additional truncations or bevelments. The broader lateral planes are streaked longitudinally, and are convex; the terminating planes smooth. Chrysolite is infusible by the blow-pipe, but its colours are changed. Its constituent parts are — Silex 38 to 39, Magnesia 39.50 to 50, Iron 19 to 9. Vauquelin. — On account of its softness, chrysolite is not highly prized by the jewellers.

OLIVINE is generally of an olive-green colour, but when decomposing it becomes irridescent, and passes to a brownish-yellow; it is translucent or semi-transparent, and rarely transparent; the lustre is shining or glistening, and is intermediate between vitreous and resinous. The fracture is conchoidal or uneven. Crystallized olivine has a more or less distinct laminar structure, with a double rectangular cleavage, parallel to the lateral planes of the primitive crystal. It is extremely brittle; and rather less hard than chrysolite, with which it agrees in its other properties. The constituent parts, according to Klaproth, are — Silex 50, Magnesia 38.50, Iron 12, Lime 0.25.

Olivine is much intermixed with augite in the lavas of Vesuvius, the crystals being often imbedded in each other. It occurs in minute and scarcely perceptible grains, as a constituent part of many lavas. It is also abundant in many basaltic rocks in Bohemia and France, supposed to be of volcanic origin. It occurs in basaltic rocks in Durham and Northumberland, and in various parts of Scotland.

Sp. 43. CORUNDUM.

Perfect Corundum, or Sapphire.
Imperfect Corundum, or Adamantine Spar.
Granular and Imperfect Corundum, or Emery.

Corundum, *Corindon*, Haüy. — In its perfect form, as in the sapphire, corundum is the hardest and most valuable of all mineral substances, except the diamond. The sapphire, like the diamond, is remarkable for the simplicity of its composition, being essentially composed of alumine, as the latter is essentially composed of carbon. The diamond and the sapphire which rank the highest among precious stones, may truly be regarded as the wonders of the mineral kingdom. Little could we have anticipated without the aid of chemistry, that substances so rare, and possessing such extraordinary hardness and brilliancy, were formed of elementary materials, that are so commonly presented to our notice, in the soft, dull, and opaque forms of charcoal and clay.

Sapphire differs so much from common corundum in external appearance, that it is at first difficult to perceive the propriety of classing them as the same species; but this difficulty will be lessened, if we regard sapphire and common corundum, as bearing the same relation to each other, as rock-crystal to common quartz; for the difference between the most compact and opaque variety of corundum and the purest sapphire, is not greater than between some varieties of common quartz and rock-crystal; nor does emery or granular corundum differ more from coloured transparent sapphire, than impure granular quartz or siliceous sand-stone differs from the amethyst.

Common corundum may be traced through different varieties which approach to the state of sapphire, and have the same crystalline forms. The primitive form of the crystal is a rhomboid, nearly approaching to the cube, the inclination of the planes forming angles of 86° 26′, and 93° 34′. This form is easily obtained by cleavage in some of the blue and red varieties, and it is sometimes found in nature. In opaque corundum, the laminar structure is distinctly visible, the cleavages being parallel to the sides of the primitive rhomb. Some crystals present a cleavage perpendicular to the axis of the rhomb. Haüy has described five varieties of the secondary crystal; they rarely occur perfect; the two most common forms are a regular six-sided prism, the angles of which are sometimes truncated, as represented Plate III. fig. 30. 18; or the dodecahedron formed of two acute double six-sided pyramids. The summits are sometimes truncated, as represented Plate III. fig. 31. 19 The faces of the pyramid are inclined to each other on the lateral edges, at an angle of 128° 14′, and they form angles of 121° 34′, with the faces of the lower pyramid, at their common base. All the other varieties of the secondary crystals may be referred to the rhomb, the pyramid, or the six-sided prism variously modified; the sapphire also occurs in rolled pieces. The specific gravity of corundum is nearly or above 4, varying from 3.91 to 4.20; it scratches all other minerals but the diamond; it possesses a low degree of double refraction, and is infusible by the blow-pipe. The situations in which the three varieties of corundum occur, will be noticed under each.

Sapphire, or Perfect Corundum, *Telesia*, Haüy, occurs in rounded pieces and crystals in the beds of rivers, and has been found in France in the sands of a rivulet at Expailly, near Puy in Velay. It has also been found in alluvial soil, with iron-sand, zircon, and pyrope, in the environs of Merenitz, in Bohemia, and at Brendola, in the Vicentine, and in Portugal; but the finest sapphires, such as are employed by jewellers, are found in the sands of rivers in Ava, Ceylon, and Pegu. The colours of the sapphire have been already enumerated; the varieties of colour were considered by artists and by former mineralogists, as constituting different species; but nothing can more clearly prove, that the colour is only an accidental quality, than the fact noticed by Haüy, that the blue sapphires sometimes contain parts that are colourless, and other sapphires are blue in one part, and red or yellow in another. Blue and red, of different shades and degrees of intensity, may be regarded as the prevailing colours of the sapphire. The lustre is vitreous and splendent, sometimes approaching to that of the diamond. It is transparent and sometimes only translucent; its transparency and brilliancy being diminished by a milky kind of opalescence. The white or colourless sapphire has the nearest resemblance to the diamond of all precious stones. The blue sapphire varies from azure-blue to indigo-blue, or blueish-grey.* The red sapphire varies from crimson to cochineal-red; and the yellow, from the yellow of the jonquil to greenish-yellow. The white and blue varieties preserve the electricity acquired by rubbing for several hours. The constituent parts of sapphire are,

	Alumine.	Lime.	Ox. of Iron.	
Blue Sapphire -	98	0.5	1	Klaproth.
		Silex.		
Ditto - -	92	5.25	1	Chenevix.
Red Sapphire -	90	7	1.2	Chenevix.
Common Corundum	91	5	1.5	Chenevix.

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* Blue sapphire is rendered colourless by heat, and is sometimes sold for the diamond.

The asteria, or star sapphire, when cut, presents six silver-white rays, diverging at equal angles from the centre of the hexagonal prism, and perpendicular to the middle of the sides of the prism.

Common, or Imperfect Corundum, *Corindon Harmophane,* occurs amorphous and crystallized; the structure is distinctly laminar, with joints parallel to the sides of the primitive rhomb; it has an uneven and sometimes a conchoidal cross-fracture. The colours are generally dull, varying from greenish-grey, to red of various kinds; it is sometimes yellowish-grey, or inclines to blue. In the British Museum, are some masses of red corundum of considerable size, and other specimens, showing the transitions from crystallized corundum to sapphire. The forms of the crystals of corundum have been already described.

Corundum has been found imbedded in mica-slate in Italy, and in iron-ore at Fahlun in Sweden; but it occurs principally in the Indian Peninsula, and in Malabar, China, and Ceylon. In India it is found in a granitic rock composed of felspar, quartz, mica, and hornblende, and with a mineral to which Bournon has given the name of *fibrolite.** It is also imbedded in indianite.

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* Fibrolite occurs crystallized in rhomboidal prisms with alternate angles of 100° and 80°; its structure is fibrous; the colours white or grey; the lustre glistening. The specific gravity 3.21; hardness greater than quartz. Its constituent parts are — Alumine 58, Silex 38, Iron and Loss 4.

Emery, *Corindon Granulaire,* occurs in amorphous masses, and disseminated. Its structure is granular; it is frequently intermixed with mica and ores of iron; the colours are greyish-black or blueish-grey, and sometimes brownish; it is faintly translucent on the edges, and possesses a low degree of lustre. Its specific gravity is about 4.00. From its great hardness it is extensively used in polishing other minerals. The powder will cut every other substance but the diamond. It is found in Saxony with talc, steatite, and calcareous spar, imbedded in clay-slate. The emery of commerce is brought principally from Smyrna, and from the island of Naxos, where it is found in loose masses at the feet of primitive mountains. It is said also to be found in Italy and Spain. The emery from the island of Naxos contained, according to Tennant — Alumine 86.5, Silex 5, Oxide of Iron 4. In the collection of the Count de Bournon was a specimen of emery, from the island of Naxos, incrusted with tremolite, in which were several small hexahedral prisms of bright blue sapphire, a circumstance which appears to indicate the relation between this variety of corundum and sapphire.

SP. 44. WAVELLITE, or HYDRARGILLITE.

Diaspore? | *Turquoise?*

WAVELLITE, or HYDRARGILLITE, generally occurs in mamillated or hemispherical concretions, varying in size from that of a pea to a walnut; the concretions are composed of acicular prisms, closely adhering and diverging from the centre. Sometimes the crystals are separated; they are slender and flatly rhomboidal prisms, frequently truncated on the obtuse lateral edges. Wavellite also occurs stalactitical. The colour is yellowish or greenish-white, sometimes inclining to grey. It has recently been found red: the lustre is shining and vitreous, or inclining to silky. It is more or less translucent.

The specific gravity of wavellite is about 2.25. It scratches quartz; it is infusible before the blow-pipe, but becomes white and opaque. When a fragment is laid on glass and heated, and a drop of sulphuric acid poured upon it, the glass becomes slightly corroded. Wavellite, according to Davy, contains — Alumine 70, Water 26.5, Silex 6.12, Lime 1.4, Oxide of Iron 1, Loss 2.4.; but according to a recent analysis of Berzelius, it contains — Alumine 35.35, Phosphoric Acid 33.40, Fluoric Acid 2.06, Lime 0.50, Oxide of Iron and Manganese 1.25, Water 26.90. Wavellite was first discovered by Dr. Wavel near Barnstable in Devonshire. It occurs in the seams of the soft schist of that county, provincially called *shillet*. It is found in metallic veins near St. Austel, in Cornwall, and has been noticed in South America.

Diaspore appears to be a lamellar variety of Wavellite. The lamellæ are slightly curved, have a shining pearly lustre, and are easily separable from each other. Its specific gravity is stated to be 3.4. According to Haüy, the division of its planes form a rhomboid, with angles of 130° and 50°. A small fragment held for a few moments in the flame of a candle separates, with a slight explosion, into a number of minute particles. Diaspore occurs in a ferruginous clay. Its geological situation is unknown.

Turquoise, an opaque greenish-blue stone employed in jewellery. The name *turquoise* is supposed to be applied to two very different substances, the one being a true mineral, the other the bones or teeth of animals coloured by phosphate of iron. The first is called by the French *Turquoise de Vielle Reche*. According to the analysis of Johns, it contains—Alumine 73, Iron 4, Copper 4.5, Water 18.

Sp. 45. CYMOPHANE, or CHRYSOBERYL.

This mineral is nearly equal to the sapphire in hardness and brilliancy, and is employed in jewellery. The colours are a light yellowish-green: it is semi-transparent, and frequently displays a peculiar blueish-white opalescence, which seems to float in the interior of the stone. Cymophane has a splendent vitreous lustre; it also refracts doubly. Its specific gravity varies from 3.55 to 3.79. Cymophane is the hardest of all earthy minerals, except *corundum* (sapphire). The constituent parts are — Alumine 71.5, Silex 18, Lime 6, Oxide of Iron 1.5. It is infusible by the blow-pipe.

Cymophane occurs in crystals in a rock of granite, at Haddam, on Connecticut river, in the United States. The granite also contains garnets, emeralds, and tourmaline. This mineral is also brought in crystals and rounded pieces, from the Brazils and Ceylon. The primitive form of the crystal is a right rectangular prism (Plate IV. fig. 33.), in which the proportion of the edges, C and B, are as 25 to 17, and of the height G as 14. It has two cleavages, parallel to the axis, of which that parallel to the face T is more distinct than that parallel to M.* Haüy has described four secondary forms; the one called *Annulaire* is represented Plate IV. fig. 17. An explanation of the structure of this crystal will be found in Book I. p. 137 and 138.

Distinctive Characters. — Cymophane is distinguished from sapphire by its greater double refraction and its inferior specific gravity. It has no cleavage parallel to the base of the prism, as is the case with sapphire. The hardness of cymophane distinguishes it from topaz. It is also much harder, and possesses greater specific gravity than the emerald or beryl.

SP. 46. SPINEL, or SPINEL-RUBY.

Pleonaste, or Ceylonite. | *Automalite.*

SPINEL is found in small crystals and grains, in the sands of rivers in Ceylon, Pegu, and the Mysore country, together with tourmaline, zircon, and other minerals. It occurs also in the cavities of volcanic rocks near Vesuvius, and though we are at present unacquainted with the principal natural repositories of this species, it

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* The position of the base is deduced from calculation, as the joints in that direction are not discovered.

is most probable that they are volcanic or basaltic rocks.

The name of ruby is given by jewellers to two distinct species: the one called the *oriental ruby* is the red sapphire (see SAPPHIRE); the other, sometimes called *spinel-ruby* and *balas-ruby*, bears a near resemblance to the red sapphire, but it differs from it in its composition, crystalline structure, and physical properties.

The prevailing colour of the spinel-ruby is red, either rose-red, poppy-red, or cochineal-red. It is occasionally found colourless, and also blue and green; but these colours are rare. The lustre of spinel is vitreous and splendent. It is transparent or translucent, and refracts singly.

The most distinguishing character of spinel is the crystalline form; it frequently occurs in regular octahedrons; the contiguous planes meet under angles of 109° 28′; the cleavage is parallel with the planes of the octahedron; but the laminar structure is seldom distinct. It is sometimes crystallized in tetrahedrons, which are often truncated on the angles or edges. Crystals of spinel sometimes present the remarkable appearance of an octahedron cut into two segments and turned round one-sixth part of a circle, but still adhering and forming only one crystal (*spinelle transposé.*)

The specific gravity varies from 3.50 to 3.70. It is one of the hardest minerals, except the diamond, corundum (sapphire), and cymophane. The hardness of zircon and spinel are nearly equal. With the above exceptions, spinel scratches all other minerals. Its colours remain unchanged by the blow-pipe, and it is infusible. It does not become electric either by heat or friction, nor can it be made to affect the magnetic needle like garnet.

The constituent parts of spinel are — Alumine 74.5, Silex 15.5, Lime 0.75, Magnesia 8.25, Iron 1.5. Klaproth. Another analysis by Vauquelin gives — Alumine 82.47, Magnesia 8.75, Chromic Acid 6.18. The specific gravity of the latter was 3.76, of the former 3.57. It will be seen by the above analysis, that the composition differs from that of the sapphire, which is nearly pure alumine.

Distinctive Characters. — Spinel-ruby is distinguished from the red sapphire by its inferior hardness and specific gravity. It refracts singly, and the sapphire refracts doubly, but in a slight degree. Its inferior specific gravity and single refraction distinguish it from zircon hyacinth. It is harder than red topaz, cinnamon-stone, or garnet, and does not, like the former, acquire electricity by heat or friction. Its colours are more lively than those of garnet, and do not incline to yellow or orange, like cinnamon-stone.

The ruby is much employed in jewellery. In the Encyclopedie Methodique it is stated, that a fine spinel-ruby of four carats is equal to half the value of a diamond of the same weight.

Pleonaste, or Ceylonite, might not improperly be called *black spinel*, its colours being a very dark and dingy blue, approaching to black. Its crystallizations are the same as those of the spinel-ruby; the lustre is splendent and nearly semi-metallic. It was first brought from the island of Ceylon, where it occurs in crystals and grains in the same situation as spinel. It has since been found in volcanic and basaltic rocks in various parts of Europe, particularly in the cavities of volcanic rocks near Vesuvius. The constituent parts of pleonaste are — Alumine 68, Silex 2, Magnesia 12, Oxide of Iron 16.

Automalite is classed as a variety of spinel by Haüy; but as it sometimes contains fifty parts of metallic or inflammable matter, it will be described among the ores of zinc.

Sp. 47. ANDALUSITE.

Andalusite, *Feldspath Apyre*, Haüy, has been classed by some mineralogists with felspar, but it differs from that mineral in its physical properties, and, according to the Count de Bournon, in its crystalline form. It was first found in the province of Andalusia, but has since been discovered in various other countries, generally imbedded in granite, gneiss, or mica-slate. It has been found in gneiss in Aberdeenshire and at Killiney near Dublin, and in the county of Wicklow; it has also been discovered in the granite from Dartmoor.

Andalusite has not been found in very large masses. It occurs both amorphous and crystallized in rectangular prisms, sometimes laterally aggregated, but most frequently imbedded in rocks of granite, gneiss, or mica-slate. It has generally a low degree of lustre, and the colours are dull. It contains a larger portion of alumine in its composition than felspar, and is much harder. It is infusible by the blow-pipe. The andalusite of Herzogan was exposed by Bucholz to a temperature equal to that of melted silver for an hour and a half; its colour was changed, its lustre almost destroyed, but it appeared to have increased in hardness and brittleness. According to Von Voith, the andalusite of Herzogan was so soft in its native repository that it could be flattened between the fingers and cut with a knife; but it became very hard on exposure to the air. (Jameson's Mineralogy, vol. i. p. 349.)

The constituent parts of andalusite are,

	Silex.	Alumine.	Potash.	Oxide of Iron.
Vauquelin	32	52	8	2
Morveau	29.12	51.07	—	7.83

CHARACTERS OF ANDALUSITE.

Specific Gravity from 3.07 to 3.16.

Hardness greatly exceeding quartz, but scratched by spinel.

Infusible by the blow-pipe, but loses its colour and translucency.

Form. — In crystals and small masses, the crystals four-sided rectangular prisms, often truncated on the edges or angles.

Structure and Fracture. — Laminar, but not very distinct. The cleavage two-fold and rectangular, parallel to the sides of the prism. The cross fracture uneven.

Affections of Light. — Prevailing colour flesh-red, sometimes inclining to grey. Faintly translucent; the lustre vitreous and glistening.

Distinctive Characters. — The greater degree of hardness and specific gravity, and its infusibility, distinguish andalusite from felspar. Its inferior specific gravity and hardness, distinguish it from corundum and zircon.*

Sp. 48. TOURMALINE, or SCHORL.

Common Black Schorl.	*Rubellite, or Red Schorl.*
Tourmaline, Green Schorl.	

Tourmaline is remarkable as being the first mineral that was observed to become electric by heating. The tourmaline presents itself under a great variety of colours, but it may be distin-

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* In the opinion of some mineralogists, the mineral called scapolite, passes by gradation into andalusite.

Andalusite possesses too little beauty to be employed in jewellery, and has not hitherto been used in the arts. Were it sufficiently abundant, it might supply some of the purposes of emery.

guished by well-marked characters from every other mineral.

Tourmaline is most frequently disseminated through granitic and primary rocks; or it occurs in veins, either in long prismatic crystals, or in masses of greater or less size, consisting of an aggregation of slender prismatic crystals, either parallel or diverging. The crystals of tourmaline have six, eight, or a greater number of sides, and are deeply streaked longitudinally; the sides are often cylindrically convex. The crystals are generally terminated by three planes at one extremity, and by a greater number at the other. Sometimes the prisms are terminated by several planes; on attentive examination, the number will be found dissimilar at each extremity. When the tourmaline is heated between 212° and 300° Fahrenheit, it becomes electric, the opposite extremities possessing different states of electrical polarity; that extremity which has the greatest number of faces is always negatively electric, and that which has the smallest number of faces is positively electric. All the varieties of tourmaline are harder than quartz; the black or common schorl is less hard than the coloured translucent varieties.* The specific gravity of

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* In consequence of the hardness being differently represented, I made trial with Mr. Lowry of Cornish, Scotch, Swedish, German, and American black schorl, and found that they all scratched quartz sensibly.

tourmaline is about 3.20. All the varieties are fusible before the blow-pipe, except the rubellite or red schorl.

The primitive crystal of tourmaline, as indicated by the cleavage, is, according to Haüy, an obtuse rhomboid (Plate IV. fig. 11.) The inclination of the planes forming angles of 133° 26′ and 46° 34′. Of the secondary forms, Haüy has described twenty-seven varieties, two of the most common are represented Plate IV. figs. 12 and 13. Sometimes the prisms are very short, or entirely disappear.

The other characters of tourmaline will be described under each variety.

Black Tourmaline, or Common Schorl, is of a velvet-black colour; the lustre is vitreous and shining or glistening; it is opaque. Some of the black tourmalines are but feebly electric by heat. The fracture is imperfectly conchoidal, or uneven and granular. The prismatic crystals are sometimes an inch or more in diameter, but more frequently the prisms are long and slender, and when aggregated into masses, are often acicular, and are easily separable. Common schorl sometimes occurs in granular concretions, intermixed with quartz; in this state, it composes entire rocks, or is found in veins; this intermixture is called *cockle* by the Cornish miners.

The Roach-rock, near Bodmin in Cornwall, is formed of an intermixture of quartz and schorl. Schorl occurs in various parts of Cornwall, and has recently been discovered in very large crystals near Bovey Heathfield in Devonshire. Black schorl occurs in quartz veins that intersect granite, near Aberdeen.

TOURMALINE is distinguished from common schorl by the colour and a greater or less degree of translucency or transparency. The colours are green, blue, deep-blue, yellow, and red; hence tourmalines have received the name of Brazilian emerald, Brazilian sapphire, indicolite, chrysolite of Ceylon, and rubellite.

The tourmalines which are most transparent generally possess the highest electric power. Some tourmalines appear opaque when the end of the prism is turned to the eye, but are transparent when viewed through the sides of the prism. The tourmaline was first brought from the Island of Ceylon, and afterwards from the Brazils, but many of the varieties are found in various parts of Europe, and in the United States of America.

RUBELLITE, or RED SCHORL, has been classed by some mineralogists as a sub-species of tourmaline; the colours vary from a brownish or orange-red, to a deep crimson. The largest specimen of rubellite at present known is in the collection at the British Museum. It was brought from Ava by Colonel Simes. It is a mass about seven inches in height at the highest point, and measuring about seventeen inches round, being nearly triangular; it is composed of prismatic crystals closely aggregated, and adhering by their sides, but slightly diverging; the summits of the prisms rise above each other, forming a kind of pyramidal termination to the mass; each prism is also terminated by three or more planes. The colour externally is a pale reddish-brown; where a part is broken off, the internal colour inclines to red or pink. It was valued at 500*l.*

The constituent parts of tourmaline, as given by different chemists, are as under:

	Common Schorl.		Green.	Transparent Rubellite.	Opaque. Rubellite.
Silex	36	35	40	42	45
Alumine	31	31.5	39	40	30
Lime	—	0.6	3.84	—	—
Magnesia	1.25	5.93	——	Mang. 7	13
Iron	23.5	6.12	12.5	10	10
Potash	5.5	——	——	—	—

Coloured translucent tourmaline and rubellite are employed in jewellery, but the colours are not so lively as those of many other gems.

Distinctive Characters of Tourmaline. — Black tourmaline is distinguished from common hornblende, augite, actynolite, and epidote, by its superior hardness, the form of the crystals, and its deep black colour. From basaltic hornblende it is also distinguished by its superior hardness, and by the longitudinal streaks on the sides of the prism. None of the above minerals are pyro-electric like tourmaline. Coloured tourmaline may be distinguished by the pyro-electric property from all the precious stones except topaz; its dark colours further distinguish it from the topaz and emerald; its specific gravity is also greater than that of the emerald.

Sp. 49. TOPAZ.

Pyrophysalite. | *Pycnite, or Schorlite.*

This mineral is more widely distributed than most of the precious stones. The name is derived from *Topazos,* an island in the Red Sea, where the Romans obtained a precious stone, called the *Topaz,* but which was probably the chrysolite.

The prevailing colour of the topaz is yellow, varying from a very pale yellow to a deep orange. It is also found green, red, blue, and colourless. The colourless variety from Brazil is so perfectly limpid, that it has received the name of *Goutte d'eau* by the French jewellers. The lustre of topaz is vitreous and splendent. It is transparent or translucent, and refracts doubly. The specific gravity varies from 3.53 to 3.64. It scratches quartz. Topaz occurs in long prismatic crystals; also lamellar, and in rounded pieces. It is disseminated in some granitic rocks, and in veins. The crystals of topaz are sometimes of considerable size; they are rhomboidal prisms, but are generally truncated, forming prisms with six, eight, or a greater number of sides, which are longitudinally streaked. They are often terminated by a considerable number of planes, and the terminations at the opposite extremities are dissimilar. Three of the more common forms of the crystal are represented in Plate III. figs. 39, 40, 41.

Sometimes the prisms are nearly cylindrical, being deeply bevelled on all the angles, and striated. Topaz has a very distinct laminar structure, and cleavage parallel to the base of the prism. The fracture parallel to the sides of the prism is small conchoidal. The terminating planes are always smooth. According to Haüy, the primitive form of topaz is a right rhomboidal prism, with alternate angles of 124° 22′ and 55° 38′, the length of the side, as deduced from calculation, is to the height nearly as 17 to 30. *Traité des Pierres precieuses*, p. 33.

Some varieties of topaz become electric by heat: the variety called *Goutte d'eau* sometimes retains, for twenty-four hours, the electricity acquired by rubbing.

Topaz is infusible by the blow-pipe. Some varieties become colourless by heat; others become rose-red at a high temperature; and at a still higher temperature violet-blue.

Topaz has been found in small crystals on the sides of perpendicular quartz veins, that intersect the granite of St. Michael's Mount, in Cornwall. Crystals of larger size have been found in alluvial soil in Aberdeenshire.

Topaz occurs in various parts of Europe and Asia, and in South America. On the summit of a mountain in Daouria, in Siberia, near the river Amour, called *Odon Tehelon*, there is a rock composed of topaz, beryl, and quartz. The topazes are of large size and pale. A fine specimen of this rock is in the British Museum. A rock near Schneckenstein, in Saxony, contains topazes disseminated through the whole mass, and is called by Werner topaz-rock.

Topaz is employed in jewellery. Various names are given to it, according to its colour, or the place from which it is brought. Those from India, which have a deep clear orange-yellow colour, are the most valuable; they are called *Oriental topazes*, but the same name is applied to the yellow sapphire. The colour of the Brazilian topaz is less vivid. The Saxon topaz is a pale yellow. In the British Museum, there is a pale blueish-green Siberian topaz of considerable magnitude, being about five inches in length, and three inches and a half in breadth, with the terminal planes at one extremity very perfect.

Yellow quartz, when cut and polished, is sometimes sold for topaz, and the topaz has not unfrequently been sold for the diamond and sapphire.

The constituent parts of topaz, and of the pyrophysalite and pycnite, which are classed with topaz, are —

	Alumine.	Silex.	Fluoric Acid.	Oxide of Iron.	
Topaz from Brazil	44.5	47.5	7	0.5	Klaproth
	50	29	19	—	Vauquelin
Saxon	59	35	5	0.5	Klaproth
Pycnite	48	34	17	1	Bucholz
Pyrophysalite	53	34.36	7.77	—	

Distinctive Characters of Topaz. — Yellow topaz may be distinguished from yellow sapphire by its lower degree of specific gravity and inferior hardness; and the latter does not become electric by heating. Greenish-yellow topaz is softer than cymophane, and is further distinguished by its distinct lamellar cleavage. The greenish topaz is much heavier than the beryl or emerald, and it has not a distinct cleavage parallel to the axis as in the beryl. Red topaz may be distinguished from the spinel-ruby by its inferior hardness. The native red topaz always becomes electric by heat, and possesses double refraction. The inferior hardness and lustre distinguish the limpid topaz from the diamond. The diamond also possesses double refraction in a higher degree than the topaz.

The composition and structure of the two following minerals agree with those of topaz, though they differ from it considerably in external appearance.

Pyrophysalite. — This mineral has hitherto been found only at Fahlun, in Sweden. It occurs in long somewhat cylindrical pieces, which sometimes present indications of being irregular prisms, terminated like some varieties of the topaz. Externally the colour is whitish-green and the lustre dull; internally it is greenish-white, and the lustre vitreous and glistening; it is feebly translucent. The specific gravity is about 3.40. It scratches quartz. The cleavage is in a direction parallel to the base of the prism. An amorphous variety of this mineral very distinctly laminar, is called *laminar pyrophysalite;* it bears some resemblance to white felspar. Pyrophysalite is infusible before the blowpipe, but acquires a slight glazing, and disengages bubbles of gas; hence the name is derived from the Greek *pyros*, fire, and *phusalos*, a bubble.

Pycnite, or Schorlaceous Beryl, is classed by Haüy as a variety of topaz, with which it agrees in chemical composition as stated above.

Pycnite occurs crystallized in long six-sided prisms, but more frequently in irregular prisms, or cylinders united longitudinally into prismatic or cylindrical concretions deeply striated. The structure is indistinctly laminar at right angles to the axis of the prism. The longitudinal fracture is imperfectly conchoidal. The colours are yellowish or reddish-white; it is faintly translucent; the lustre is vitreous and shining or glistening. The specific gravity is 3.50. It scratches quartz feebly. Before the blowpipe it becomes opaque, but is infusible. Pycnite has a greater specific gravity than beryl. Its infusibility distinguish it from epidote or augite. It is pyro-electric. It has been found in rocks composed of quartz and mica, in Saxony, Bohemia, and France, and also in Siberia.

SP. 50. SAPPARE, or DISTHENE.

SAPPARE, OR DISTHENE, *Kyanite*, Werner. — This mineral frequently occurs in long flat prismatic crystals, imbedded in mica-slate or talc-slate, and is also found in amorphous masses generally composed of long and curved laminæ, promiscuously diverging and intersecting each other. The prevailing colour is light-blue or blueish-white; the lustre is shining and pearly, and is transparent or translucent. A blueish-white and splendent variety from the Tyrol has been called *Rhætizite*.

The more common forms of the crystals are long oblique four-sided prisms truncated on the acute lateral edges; sometimes all the edges are truncated, and sometimes a twin-crystal is formed by two prisms, which adhere by their broadest sides. The primitive crystal, according to Haüy, is an oblique four-sided prism; the lateral planes of the prism are inclined at angles of 102° 50′ and 77° 30′, and the base forms angles with the lateral planes of 106° 6′ and 73° 52′. It has a threefold cleavage parallel to the planes of the primitive crystal, but that parallel with the broadest planes is the most distinct.

The specific gravity is 3.50; the lateral edges of the laminæ scratch glass, the broader lateral faces are scratched by a knife, but the smaller planes are not; before the blow-pipe it is infusible. According to Klaproth, it contains — Silex 43, Alumine 55.50, Iron 0.50.

Sappare is frequently accompanied by garnets and staurotide: indeed the latter mineral seems to identify itself with ~~staurotide~~ sappare, as crystals sometimes occur, one end of which are sappare and the other staurotide; the different colours of these two minerals make this junction the more remarkable. Sappare is found at Boharn, Bamfshire, and in Aberdeenshire, but the most beautiful crystals are from Mount St. Gothard; it is also found in Asia, and various parts of the United States. Indian artists sometimes cut and polish sappare, and pass it off as an inferior sapphire. M. Haüy informs us, that he has frequently undeceived persons possessing these false sapphires, by cutting them through with a knife. Sappare possesses the remarkable property of becoming both positively and negatively electric by rubbing.

Sp. 51. STAUROTIDE, or GRENATITE.

Staurotide, or Grenatite, occurs in dark reddish-brown prismatic crystals, which are nearly opaque; the prisms sometimes intersect each other forming a cross. The common form of the crystal is either a rhomboidal or hexahedral prism, frequently two of the sides of the prism are broader than the others. One of the prisms is represented Plate IV. fig. 27.; it is truncated on the obtuse solid angles; sometimes the truncations are larger, forming dihedral summits; sometimes the prisms cross each other either at angles of 60° or 90° (Plate IV. fig. 28.)

The primitive form of the crystal, according to Haüy, is a right rhomboidal prism, with alternate angles of 129° 30′ and 50° 30′, and the height is one-sixth the acute diagonal of the base. The structure is indistinctly laminar. The cross fracture is imperfectly conchoidal or uneven.

The surface of the crystals is often smooth and shining, and the lustre between vitreous and resinous. Sometimes the surface of the crystals is rough and dull.

Its specific gravity is 3.30; it is harder than quartz, but extremely brittle. The constituent parts, as given by Klaproth, are — Alumine 32.25 to 41, Silex 27 to 37, Oxide of

Iron 18 to 18.25, Magnesia 0.25, Iron 2 to 2.75. It is infusible before the blow-pipe.

Staurotide is found with sappare at St. Gothard, and in various parts of Switzerland, and in Spain and France; it has also been found at Glenmalar lead-mines in the county of Wicklow.

Sp. 52. ALUM-STONE.

Alum-Stone is of a reddish-white colour, and spotted brown or red. It occurs either in veins or hollows in volcanic rocks, at Tolfa in Italy, and forms beds in Upper Hungary. It has a dull lustre, and an uneven earthy fracture. The alum-stone of Tolfa is composed of Alumine 19, Sulphuric Acid 16.50, Potash 4, with about 56 of Silex. — Thus it may be observed that this mineral contains all the materials of alum, and is free from iron, which greatly injures the quality of alum, when employed by the dyers; according to Thenard, one-thousandth part of alum produces a sensible effect in dyeing.*

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* *Observations on Compounds of Silex and Alumine.* — Silex and alumine comprise a variety of soft earthy substances which generally absorb water, and are plastic, and in common language are denominated clays. They contain silex in a finely comminuted state, intermixed with alumine, lime, magnesia, and iron, in various proportions, and may more properly be regarded as mechanical admixtures,

Sp. 53. ZIRCON.

Zircon-Hyacinth. | *Zirconite.*

Zircon and Jargon. — This mineral has not hitherto been found in masses of any considerable size; it occurs disseminated in certain rocks, either in crystals or grains, and is also obtained from the sands of rivers, in various parts of the the world. Though zircon may be considered as rather a rare substance in nature, it is possessed of certain physical and chemical properties, that claim the particular attention of the mineralogist. Zircon is principally composed of a peculiar earth which has not been discovered in any other species of mineral. Zircon is the heaviest of all earthy minerals, its specific gravity ranging from 4.55 to 4.72; it scratches quartz with great ease, and is equal in hardness to some varieties of spinel, being the hardest mineral, whose specific gravity exceeds 4.50. When sufficiently transparent to transmit the rays of light, zircon possesses the property of double refraction in the highest degree.

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or as earthy compounds, than as simple mineral species. The principal of these are lithomarge, fuller's-earth, porcelain-clay, potter's-clay. They will be described with earthy compounds in the Appendix.

The above properties serve to distinguish zircon from all other minerals, and from every species of precious stone, whether in a native state, or cut and polished by the jeweller.

The primitive form of the crystal is an octahedron composed of two pyramids that have similar and equal triangular faces (Plate III. fig. 29.) The angles formed by the incidence of the faces of the upper and lower pyramid P P′, at their common base, is 83° 38′. The angles formed by the incidence of the faces of the same pyramid, at their lateral edges, is 124° 21′. Primitive crystals of zircon are found at Expailly in France.

The colours of zircon are various, but generally pale and smoky; it has a high degree of lustre. The colours of some of the varieties are destroyed by heat, but the transparency is preserved; hence zircon is sometimes sold for the diamond. The varieties of zircon are not numerous, but they present a remarkable difference in colour and transparency, and have been sometimes divided into three sub-species, but their composition and essential properties are the same, and they occur in the same native repositories. Most of the rocks and sands in which zircon is found, are considered by geologists as of volcanic origin.

Zircon was first found in the sands of rivers in the Island of Ceylon, an island so abundant in precious minerals; it is accompanied by sapphires, spinel, tourmaline, garnets, and iron-sand. It has been found in the sands, supposed to be volcanic, near Expailly in Auvergne. It occurs also in the basaltic lava of that district, and in similar repositories in Bohemia, Portugal, and Spain. It occurs in a rock of sienite at Frederic-Scherwin in Norway, and was found in a mass of sienite in the county of Galway, by Professor Jameson; and has since been discovered in the granite of Criffel in Dumfries-shire. Zircon is found in New Jersey and Connecticut in the United States of America, where it occurs in crystals imbedded in felspar or quartz.

COMMON ZIRCON presents all the various shades from colourless to dark reddish-brown, and is sometimes greenish-blue or red. It varies likewise in transparency from limpid to nearly opaque; the dark-brown being only slightly translucent. Several varieties presenting these transitions, may be seen in the collection at the British Museum.

The common secondary form of the crystal is a rectangular prism, terminated by two pyramids (Plate III. fig. 30.); the pyramids are in fact the primitive faces of the octahedron, separated by a prism. *Zircon prismé* of Haüy. The faces of the pyramids form angles with the lateral planes of the prism of 130° 39′. Sometimes the edges or angles are truncated.

The structure is indistinctly laminar, with a cleavage parallel to the lateral planes of the prism. The cross fracture is flatly conchoidal.

Zircon-Hyacinth. — The prevailing colours are yellowish, or orange-red, reddish-brown, or flesh-red; it is more or less transparent. The secondary form of the crystal is a rectangular prism, terminated by four rhombic faces (Plate III. fig. 31.) The plane angles at the summit are about 73½°. The edges or angles are sometimes truncated. The structure is more distinctly laminar than in the preceding variety.

The hyacinth of the jewellers is frequently not the true hyacinth, but the cinnamon-stone.— See *Cinnamon-Stone.*

Zirconite is the reddish-brown and nearly opaque variety of zircon found in Norway.

The constituent parts of zircon are as under:

	Zircon from Ceylon.	India.	Hyacinth, Ceylon.	Hyacinth, Expailly.	Zirconite, Norway.
Zircon	68	64	70	65.5	65
Silex	31.5	32	25	31	33
Iron	0.5	1.5	5	1.5	Mag. 1

Distinctive Characters of Zircon.— These are the high degrees of specific gravity, and double refraction before described.*

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* The earth zircon was discovered by Klaproth in 1789, in a stone of this species from Ceylon; it has the harsh feel of siliceous earth, but it is fusible at a high temperature into a light-grey coloured mass that scratches glass.

Sp. 54. EMERALD.

Beryl.

Emerald, *Emeraude Verte,* Haüy. — This beautiful mineral is characterised by its pure and vivid green colour, which has received the name of emerald-green. The beryl is a variety of emerald with generally a pale green colour, and hence was formerly considered as a distinct species.

Emerald occurs crystallized in low regular six-sided prisms, which is the primitive form.* Sometimes either the lateral or terminal edges are truncated, and sometimes the angles are truncated. The laminar structure is indistinct, but is parallel to the sides and terminal planes of the primitive crystals; the cross fracture is uneven or imperfectly conchoidal. The internal lustre of emerald is vitreous and splendent, or shining; it is transparent or translucent, and refracts doubly. Its specific gravity varies from 2.66 to 2.77. The hardness of emerald, though inferior to most of the precious stones, is greater than that of quartz. The constituent parts of emerald are —

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* In the primitive form, the height of the prism is equal to the breadth of the lateral planes.

	Emerald.		Beryl.
Silex	64.50	68.50	68
Alumine	16.00	15.75	15
Glucine	13.00	12.50	14
Oxide of Chrome	3.26	0.30	—
Lime	1.60	0.25	2
Water	2.	——	—
Oxide of Iron	——	1.	1
Loss	——	1.70	—
	100.36	100.	100

From these analyses it appears, that the colouring matter of the emerald is chrome. It is asserted by Berthollet, in opposition to the opinion of Haüy, that the colouring matter is a constituent part of the emerald (*Tableau Comparatif*, p. 159.)

In the collection of Mr. Lowry, there is a polished specimen which appears to decide the question, and to prove that chrome is not an essential part of this mineral; for one part of the stone is a pure emerald-green, and the other is perfectly colourless, and what is remarkable, the green colour terminates almost abruptly without gradation, sending off short branches into the colourless part. The intermixture of various shades of green in emerald, is not uncommon, and it was observed by the Spaniards who first visited Peru, that some of the emeralds were colourless or pale-green; and they supposed, that these were unripe emeralds, and that they would acquire a green colour by solar heat. With the precise geological situation of the green emerald of Peru, we are not well acquainted.* A fine specimen in the British Museum, which is an hexagonal prism, nearly two inches in breadth, is partly imbedded in carbonate of lime. Another emerald from Santa Fé, between the mountains of New Grenada and Pompayan, is partly imbedded in carbonate of lime, intermixed with sulphuret of silver. These specimens are probably from veins. The emerald occurs also imbedded in granite, as pale emerald or beryl, according to professor Cleaveland, is found in granite in various parts of the United States, and is sometimes accompanied with dark-green emerald. Emeralds occur imbedded in mica-slate at Salzburg, but their colour is pale. The emerald has been long highly valued as a gem. According to Pliny, the Emperor Nero made use of a concave polished emerald, to observe the combats of the gladiators, on account of the shortness or weakness of his sight, but whether it served the purpose of a lens or a mirror is not clearly ex-

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* The Spaniards found in one of the Peruvian temples a magnificent emerald, which was called *The Mother of Emeralds*, and worshipped as a divinity; it was about the size of an ostrich's egg, and was surrounded by smaller emeralds. (Acosta Hist. Peru.) What has become of this emerald?

pressed. If we suppose that it was employed as a lens, we must grant this tyrant more than half the honour of being the inventor of green spectacles. '*Nero princeps gladiatorum pugnas spectabat Smaragdo.*' (Plin. Hist. Nat. lib. xxxvii.)*

The circumstance of a new earth glucine being discovered in the emerald and the beryl, must not pass unnoticed. This earth has hitherto been found only in one or two other minerals; its properties nearly resemble those of alumine; it combines with acids, and forms combinations which have a sweet or rather astringent taste; hence its name, which is derived from the Greek *glucus*, signifying *sweet.*

Beryl, sometimes called *Aqua Marine*, is found in various parts of Europe. In Aberdeenshire it occurs in alluvial soil, with topaz and rock-crystal: it is found also in the county of Wicklow in Ireland. Beryls of large size occur in granite near to Limages; the crystals are sometimes more than a foot in length, and six inches in diameter. The finest beryls come from Dacina in Asia. Beryls of considerable size have been found in various parts of the United States of America, some being more than a foot in dia-

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* There can be no doubt that the smaragdus and beryllus of Pliny, were the emerald and the beryl of mineralogists; he describes the refreshing effect of the green colour of the emerald on the eye, and the hardness and hexagonal form are particularly noticed. He says the finest emeralds came from Scythia.

meter; they are not unfrequently accompanied with crystals of a deep green colour, like the precious emerald. According to Professor Cleaveland, a rose-coloured emerald, one inch in diameter, has recently been found at Chesterfield, in Hampshire county, in Massachusetts. In all the instances in which the beryl and emerald have been found in the United States, they occur in granite, or in gneiss, or in granite veins that traverse gneiss. The colours of the beryl are sometimes impure, and also vary in the same crystal; they are generally pale, on which account its value in jewellery is much less than that of the emerald. The large crystals of beryl present some remarkable appearances, being sometimes nearly cylindrical, and are also curved; sometimes they are articulated or jointed, having a convex surface at one extremity of the prism, and a concave one at the other; the crystals are often collected in groups or intersect each other. The prismatic crystals of beryl are longer than those of the emerald, and the cleavages are more distinct; they are parallel to the sides and terminal planes of an hexagonal prism.

Distinctive Characters. — The beryl may be distinguished from pycnite, topaz, and the green tourmaline by its inferior specific gravity, and by its exhibiting no signs of electricity by heat, like the latter mineral. It may be distinguished from apatite by its greater degree of hardness, the latter being softer than fluor-spar.

Sp. 55. EUCLASE.

Euclase. — This mineral is the most brittle of all the precious gems, and has received its name from the Greek verb *klaso*, designating this property, being very easily divisible by two cleavages at right angles to each other. It is brought from Peru and the Brazils, and has hitherto only been found crystallized; the primitive form is a right rectangular prism. Some of the secondary forms are complex; there is one with seventy-eight faces, having fourteen for the prism, and thirty-two for each of the extremities. The colour of euclase is a beautiful light-green; it is perfectly transparent, has a splendent lustre, and refracts doubly in a high degree; it takes a high polish. The specific gravity is from 2.90 to 3.06. It scratches quartz; but, on account of its extreme brittleness, is difficult to cut for jewellery. There is a brilliant specimen of euclase in the British Museum, about the size of a large bean. Euclase loses its transparence before the blow-pipe, and then melts into a white enamel. Its constituent parts, according to a very recent analysis of Berzelius, are — Silex 43.32, Alumine 30.50, Glucine 21.78, Oxide of Tin 0.71. The glucine in this mineral appears to connect it with the emerald. The double refractive power of the euclase, according to Haüy, equals or exceeds that of all other earthy minerals.

Sp. 56. CARBONATE of LIME.

Crystallized, or Calcareous Spar.
Fibrous.
Lamellar.
Stalactitical.
Oviform, or Globular.
Compact Lime-stone.
Bituminous Lime-stone.
Earthy.
Soft, or Friable.

Carbonate of Lime, *Chaux Carbonatée.* — The natural history of carbonate of lime is intimately connected with that of the globe itself, and of its earliest inhabitants; vast mountains and extensive beds and strata of lime-stone cover a large portion of the present islands and continents. Many of these beds of lime-stone appear to be almost entirely composed of the shells or exuviæ of different species of marine animals; hence we learn that they were originally formed at the bottom of the ocean, though some of these beds are several thousand feet above the present level of its surface. Even in the beds of lime-stone which have a crystalline structure, some vestiges of marine shells may occasionally be observed; hence we are led to infer that this lime-stone has also had a similar origin, though the process which has given a crystalline structure to the mass, has nearly obliterated the vestiges of its animal formation. Nor does the magnitude or extent of the rocks and strata of lime-stone render their origin from marine shell-fish and zoophytes less probable, as we know that there are in our present seas, beds of oysters of great thickness, covering a surface of several hundred square miles, and reefs and islands of coral are now rising from unknown depths, and rapidly and extensively spreading in the Southern Pacific; these serve to show that this mode of formation is adequate to the production of the loftiest mountains.* Lime, however,

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* Shells, coral, and other exuviæ of marine animals, contain the same constituent ingredients as lime-stone, intermixed with a small portion of animal matter, and their transition into the finest varieties of lime-stone or statuary marble is not so extraordinary as many changes observable in the mineral kingdom. It would not be difficult to conceive, that any cause which could effect a disintegration of the shell or coral, would be sufficient to form the earthy varieties of lime-stone; for from the partial solubility of carbonate of lime in water, the particles would soon be united into one compact mass. In some varieties of lime-stone, as in the grey encrinal-marble of Derbyshire, and Craven in Yorkshire, the animal remains are nearly broken and aggregated, and the whole mass has a crystalline structure.

The crystalline structure of lime-stone may, in some instances, be effected by the crystalline polarity of the particles of lime-stone at the common temperature of the earth; in other instances, it may have been promoted by the agency of subterranean fire. Of the former, we have instances in calcareous stalactites; these we know are formed by successive depositions of earthy matter, but in process of time the stalactite acquires an internal crystalline structure, exists in various minerals to which we cannot ascribe an animal origin, and as it is one of the most abundant earths, next to silex and alumine, it is not necessary to suppose that all beds and mountains of lime-stone have been originally formed of marine shells; they are coeval with the other mountain masses with which they are surrounded.*

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and will break into the primitive rhomboid of calcareous spar. Nor have instances been wanting of oyster-shells, which appeared to have undergone no external change, presenting, when broken, an internal crystalline structure and faces of the primitive rhomboid. The experiments of Sir James Hall prove that earthy lime-stone or chalk will acquire a crystalline structure, when exposed to a high temperature, under a compression sufficient to prevent the escape of the carbonic acid; and Dr. Macculloch, in an interesting Paper on the Geology of the Isle of Skye, has described the change of a grey earthy lime-stone into white statuary marble, near its contact with trap, which was probably a volcanic lava. A similar effect is produced by basalt on the coast of Antrim, where it passes in veins through the chalk; the latter being changed into crystalline or granular lime-stone to a certain distance on each side of the vein, until the effect gradually disappears, and the chalk assumes its common earthy aspect.

* Carbonate of lime, in a state of mud, is sometimes thrown out of volcanoes, particularly from the mud volcano of Maraluba in Sicily. Beds of granular lime-stone often alternate with mica-slate; and, in some instances, as at Dalmally in Argyleshire, I have observed several layers of granular lime-stone not exceeding the thickness of a wafer, regularly alternating with mica-slate. The lime-stone so situated, is evidently coeval with the slate.

Carbonate of lime, in its purest form, as calcareous spar, is essentially composed of 57 parts of lime, and 43 of carbonic acid; or, according to some analysists, of 56 parts lime, and 44 carbonic acid. It preserves nearly the same proportion of its constituent parts, under many of the numerous forms in which it is presented to our notice. Under all its different forms it also preserves certain definite characters which enable us to recognise the varieties of this species. The specific gravity of carbonate of lime varies from about 2.50 to 2.80. The more earthy or porous varieties are under 2.50, and some impure lime-stones exceed the specific gravity of 2.85. They may all be scraped with a knife, and except when hardened by an admixture of silex, they are softer than fluor-spar. They are infusible before the blow-pipe, but become caustic. When a drop of acid is applied on the surface, an immediate effervescence takes place, and they dissolve in nitric or in muriatic acid. The characters of specific gravity, hardness, and effervescence with acids, taken collectively, distinguish carbonates of lime from all other minerals. There are, however, two minerals, arragonite and dolomite, which, though principally composed of carbonate of lime, rank as distinct species; for distinguishing these, other distinctive characters are required.

Calcareous Spar, *Chaux Carbonatée crystallizé*, Haüy, *Kalkspath*, Werner, is colourless, or more frequently tinged with yellow, and is transparent or translucent; it also occurs of various shades of brown, red, green, and yellow. The more transparent varieties possess the property of double refraction, and have a high degree of lustre. It breaks very easily into rhomboidal fragments that have three distinct cleavages parallel to the sides of the primitive crystal, which is a rhomb, the planes being inclined at angles of 105° and 75°. The plane angles of the rhombic faces are 101° 52′ and 78° 8′. In some of the primitive rhomboids of calcareous spar a third cleavage may be observed parallel to the short diagonal of the rhomboid. The cross fracture of calcareous spar is difficult to obtain, on account of the facility with which it splits in the direction of its laminæ.

The secondary crystals of calcareous spar are often large and well defined, but their variety is so great, as almost to appal the courage of the student. The Count de Bournon has given drawings of 710 different secondary crystals of this mineral in his *Traité de Minéralogie;* these he has arranged under three modifications of the primitive form: 1st, rhombs varying from the primitive form; 2d, prismatic crystals; and 3d, pyramidal crystals. Plate III. figs. 3. to 7. represent the primitive rhomboid of carbonate of lime inclosed in the six-sided prism. The manner of extracting the primitive crystal by mechanical division is explained in p. 111. Plate III. figs. 14. to 22. represent some of the principal and most common secondary forms of the crystals.*

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* Calcareous spar not only presents a greater variety of secondary forms than any other known mineral, but in each of these forms, the primitive crystal is most easily obtained by mechanical division. It was the study of the crystalline forms of this mineral that furnished the basis and developement of Haüy's theory of decrements. It may not be improper to repeat here, that by a rhomboid Haüy always means a figure bounded by six equal rhombic faces; according to this eminent crystallographer, the incidence of the planes form angles of 104° 28′ 40″, and 74° 31′ 20″; and the obtuse plane angle at the summit A is 101° 32′ 13″, and the lateral angle E, 78° 27′ 44″. According to Dr. Woolaston, the angles taken by the reflecting goniometer give the incidence of the planes 105° 5′ and 74° 55′, and the plane angles 101° 52′ and 78° 8′. The primitive rhomb is always supposed to be situated with the two obtuse solid angles A A′ in a vertical direction, as represented in Plate II. fig. 13; the three lateral angles nearest the summit are marked E, and the three others *e*. A six-sided prism may be formed by a decrement of one range on all the lateral edges of the rhomb; the structure of this is described in p. 105. The symbol of this variety is $\overset{1}{D}$ P. — (*Chaux Carbonatée Prismé.*)

Another six-sided prism formed by decrements on the angles is called *Chaux Carbonatée prismatique*, (Plate III. figs. 3 and 4.); the lateral planes of the prism are formed by a decrement of two ranges on the lateral angles of the rhomb, and by a decrement of one range on the summit of the symbol $\overset{2}{e}\,\underset{1}{A}$.

Plate III. fig. 14. *Chaux Carbonatée equiaxe.* This is a flat rhomb formed by a decrement of one range on the

The specific gravity of calcareous spar is about 2.70; it is scratched by fluor-spar, and yields easily to the knife. The constituent parts, as given Dr. Woolaston, are — Lime 56, Carbonic Acid 44. With this analysis all pure carbonates of lime nearly agree.

GRANULAR LIME-STONE, *Chaux Carbonatée saccaroide.* — This variety of lime-stone frequently occurs in beds of mica-slate or clay-slate, or al-

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upper edge B, its symbol is $\underset{1}{B}$; the inclination of the planes form angles of 134° 57′ and 45° 3′. The horizontal diagonal is double that of the nucleus; its axis is the same as that of the primitive crystal.

Fig. 15. *Chaux Carbonatée inverse.* The plane angles of this crystal are equal to those formed by the incidence of the planes in the primitive nucleus, 105° and 75°; and reciprocally, the incidence of the planes are equal to the plane angles of the nucleus, or 101° 52′ and 78° 8′; the horizontal diagonal is three times greater than that of the nucleus; its symbol is $E^{1}\,{}^{1}E$.

Chaux Carbonatée cuboide varies only by a little more than 2° from the cube; its symbol is $\overset{\frac{4}{5}}{e}$.

Chaux Carbonatée metastatique, (Plate III. figs. 7 and 17.) see p. 106. The incidence of the planes in each pyramid on their lateral edges form angles, one of 144°·24′, the other of 104° 38′. The axis of the secondary crystal is three times the length of that of the nucleus. Its symbol is D^{2}.

Chaux Carbonatée dodecahedre (fig. 18.), is a prism with pentagonal planes both on the summits and sides; its symbol is $\overset{\underline{2}}{e}\;\underset{1}{B}$.

Chaux Carbonatée dilatée (fig. 19.), *Bibinaire* (fig. 20.), *Hyper-oxidé* (fig. 21.), *Analogique* (fig. 22.), present a greater complexity of form. See Haüy Traité, tom. ii. p. 130, &c.

ternating with other schistose rocks in alpine districts. When the structure is coarsely granular, it presents the appearance of distinct laminæ promiscuously aggregated; when the grains are fine, it bears a striking resemblance to loaf-sugar, and when the grains are very minute, it appears nearly compact. The colours are most frequently white or grey, and sometimes veined or spotted. White granular lime-stone is well known as the marble employed in statuary; it is always more or less translucent; the cohesion of its grains and consequent hardness is variable. It not unfrequently contains an admixture of mica, silex, or serpentine, which impair the purity of its colours or destroy the perfect uniformity of its texture, and render it unfit for the nobler objects of the sculptor.

No beds of white granular lime-stone or statuary marble have been found in England or Wales, but they occur in the alpine parts of Scotland. Beds of granular lime-stone of a greyish-white colour, alternate with talcous or chlorite slate, in the grounds of the Duke of Argyle, near Inverary Castle. White marble is found in Tiree and other of the Scotch Hebrides, also at Glentilt, Ballaculish, and other parts of the Grampian mountains. The beautiful rose-coloured marble of Tiree, is translucent and nearly compact; it is spotted with hornblende and sahlite.

The granular lime-stone of Glentilt is large-grained, and frequently spotted with serpentine, and contains brilliant scales of mica. Though many of these marbles might be employed for chimney-pieces and in ornamental architecture, yet the expense of land carriage to the nearest port, would render them dearer than the marbles procured from the shores of the Mediterranean.

The best statuary marble employed by the moderns comes from Carrara in Tuscany, the *Luna* of the ancients. It is said, the quarries were worked in the time of Julius Cæsar. Fine statuary marble abounds in the Island of Paros, and various islands in the Grecian Archipelago. The Parian marble is of a fine grain, and very durable. The Pentelican marble, from Mount Pentelicus near Athens, was much employed in sculpture in the time of Pericles; but it is liable to partial decomposition from the inequality of its texture; hence many of the works of the most celebrated sculptors executed in this marble, are much defaced by time, whilst those of Parian marble are perfect. We have proofs of the decomposition of Pentelican marble, in the statue of Theseus, and in other statues brought from Athens by Lord Elgin, and now in the British Museum. It should, however, be remarked, that though the metopes, which represent the combats of the Centaurs and Lapithæ, are mutilated by violence, the remaining parts are nearly as perfect as when they were first executed; and if they be of the same marble, we must admit, that the quarries of Mount Pentelicus contained some stone equal in texture and durability to that of Paros.

FIBROUS LIME-STONE. — The finest variety of fibrous lime-stone is known by the name of *satin spar;* it occurs in thin strata, or veins composed of very minute capillary prismatic crystals, which are parallel and closely adhering, and generally more or less waved; it has a silky chatoyant lustre, and admits of a fine polish. It is generally white, but sometimes of a rose-red colour, probably derived from manganese; as an analysis of this stone by Holme gave Carbonate of Lime 95.75, Carbonate of Manganese 4.25. Satin spar occurs between layers of a soft dark shale, at Alston in Cumberland.

Coarsely fibrous lime-stone, consisting of irregular prisms, either parallel, diverging, or intersecting each other, is not unfrequently found between the strata or in the fissures of lime-stone; it occurs in Derbyshire, and in the magnesian lime-stone of Sunderland, and in the lias lime-stone at Lyme in Dorsetshire. Some varieties of stalactites have also a fibrous structure. See STALACTITES.

LAMELLAR LIME-STONE, or SLATE-SPAR, *Chaux Carbonatée Nacré,* Haüy, *Schiefer Spar,* Werner. — This variety has a curved and coarsely lamellar structure approaching to slaty; its colours are snow-white, or white tinged with red, yellow, or grey; the lustre is pearly and glistening, or shining; it is feebly translucent. It effervesces violently in acids; the component parts are the same as common carbonate of lime, but sometimes intermixed with a small portion of manganese, or oxide of iron. It is found at Glentilt in Perthshire, and in Cornwall.

STALACTITICAL LIME-STONE, *Chaux Carbonatée Concretionée,* Haüy, *Kalk Sinter,* Werner.

STALACTITES are formed on the roofs of caverns by water that infiltrates through limestone rocks, and contains minute particles of calcareous matter, which are deposited when the pendant drops evaporate, and form at first a small circle or button; these enlarge by successive depositions. Sometimes the stalactites are hollow or tubular, but more frequently solid and generally tapering; when very large they are often rounded at the extremities, or what is denominated claviform. Small stalactites are frequently formed under the arches of bridges or aqueducts, by the water infiltrating through the mortar, a fact which shows the mode of formation of these depositions, and that it is now going on wherever water can percolate slowly through calcareous earth.

Stalagmites are similar depositions from the water which drops on the floors of caverns, and sometimes forms large masses with very fantastic shapes. The entire cavities of caverns are sometimes nearly filled by these deposits, in the lapse of ages. It has been before observed, that stalactitical lime-stone acquires in process of time a crystalline structure, which is a convincing proof, that the power of crystalline polarity is sufficient to change the arrangement of the particles of solid bodies. Thus these calcareous depositions often acquire a fibrous radiated structure, or are granular or lamellar; they also vary in colour, translucency, and hardness; hence some of them are susceptible of a high polish, and are employed for ornamental sculpture under the name of *alabaster*. The term alabaster is, however, often applied to gypsum or the sulphate of lime. Depositions of calcareous stalactites and stalagmites are common in caves in calcareous districts; but can no where be seen in greater perfection than in the cavern called Pool's-Hole in Derbyshire, and at Yordas-Cave, near Ingleton, in Yorkshire.

POROUS OR TUFACEOUS LIME-STONE is formed by calcareous depositions from the waters of rivers or springs, holding a large portion of calcareous earth in suspension, which is deposited in the beds of rivers, or in low grounds at no great depth, below the present surface. These depositions are generally porous or cellular, and more or less friable, with a dull earthy aspect.

Sometimes, however, they form beds of considerable thickness, and are sufficiently firm for durable building-stone. There is a formation of this kind, near Stroude in Gloucestershire, and a large building employed as a woollen factory, belonging to F. Hicks, Esq. is constructed of this stone; it is observed to harden by age, and contains river shells, and leaves of the alder, with the most delicate fibres perfectly preserved. The calcareous tufa, so extensively employed in architecture in some parts of Italy, is known under the name of *travertino*; it is probable, that the hardness of this stone is derived from the infiltration of volcanic waters holding silex or other earths in solution.

OVIFORM OF GLOBULAR LIME-STONE. — Carbonate of lime sometimes occurs in globular concretions imbedded in earthy lime-stone; when these concretions are small, they bear some resemblance to the roes of fishes; hence one variety of this lime-stone has been called *roe-stone* or *oolite*; when the concretions are as large as a pea, it has been called *pisolite*, or pea-stone. Globular lime-stone occurs also in concretions several inches in diameter, particularly near Sunderland. The form is often perfectly spherical, and sometimes a number of these balls are aggregated, composing botryoidal masses. They occur in a stratum of calcareous sand; their structure is curvedly lamellar, and sometimes prismatic and radiated.* Various conjectures have been offered respecting the formation of roe-stone, pea-stone, &c.; but the true solution, I am persuaded, will be found in that peculiar kind of crystallization which disposes so many other minerals to take a spherical form, composed of concentric lamellæ and divergingly fibrous. This process seems to require that the substances which crystallize, should be surrounded by matter of a similar kind, which has a greater or less tendency to yield to the force of crystalline polarity, and it will be found on attentive examination, that the globules are large in proportion to the softness of the mass in which they are imbedded: thus the large globular concretions near Sunderland, occur in strata of loose calcareous sand.

COMPACT LIME-STONE comprises a great variety of calcareous beds or strata both among the lower and upper rock formations, which may be observed to pass from the purest and finest-grained marble, into a compact translucent lime-stone, and thence through numerous intermediate gradations into coarse earthy lime-stone or chalk. Among the different lime-stones which are called *compact*, mineralogists also enumerate many that are imperfectly granular or lamellar, being partly earthy and partly crystalline; indeed such is

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* See Introduction to Geology, 2d Edition, p. 464.

the tendency of the particles of the carbonate of lime to crystallize, that there are few kinds of lime-stone, except chalk, which do not in some parts of an extensive stratum present indications of a crystalline structure. The colour of compact lime-stone is as various as its texture. In some the colouring matter is iron or manganese; in the black or dark lime-stone it is often bituminous. Compact lime-stones also differ in purity from an admixture of silex or alumine, and when very impure, they are fusible; hence such lime-stone forms a kind of slagg in burning, and becomes unfit for the purpose of agriculture, or for mortar.*

COMPACT VARIEGATED LIME-STONE, *Transition Lime-stone* of some geologists, has a flat conchoidal or uneven fracture; it is translucent on the edges; the colours are, grey, red, brown, and black, and variously striped and spotted; it is much intersected by veins of calcareous spar, which are generally white. It occurs in

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* Under all its different appearances, the three characters before mentioned distinguish lime-stone from other minerals, namely, a specific gravity varying from near 2½ to near 3, yielding readily to the point of a knife, and effervescing in acids. The quantity of earthy impurity in lime-stone is easily ascertained by dissolving one hundred grains, or any given quantity, in dilute muriatic acid, and weighing the undissolved part after it has been washed and dried, taking care that the acid be rather in excess, so that the whole of the lime may be dissolved.

beds of considerable size alternating with clay-slate and other schistose rocks; it contains but few organic remains. This variety occurs in Devonshire, particularly at Babicomb-Bay and near Plymouth; it takes a high polish, and is employed for chimney-pieces and ornamental sculpture.

BLACK LIME-STONE, or MARBLE, *Lucullite* of some mineralogists. — This variety possesses a greater degree of specific gravity than any other, approaching to 3.0; it takes a very high polish. The most perfect black marble in England is procured from the alpine part of Yorkshire, adjoining Westmoreland; it is extensively worked by Mr. Francis Webster, of Kendal, who first discovered it, forming a very extensive stratum, ranging through the middle part of Ingleborough, and other mountains in that district.

Some varieties of black lime-stone yield a fœtid odour when rubbed; but this is not peculiar to black lime-stone. The reddish-brown magnesian lime-stone of Sunderland, possesses this property in a high degree.

FŒTID LIME-STONE, or SWINE-STONE, is that variety of lime-stone which yields a fœtid odour when rubbed, described above.

Of other varieties of compact lime-stone we might enumerate a grey lime-stone, abounding with organic remains, and in some parts coarsely granular or lamellar; such as the encrinal-marble of Derbyshire and Craven, the grey lime-stone of Dudley in Staffordshire, &c. &c. Some of these beds, from the quantity of shells they contain, have been called *shell lime-stone,* a name frequently applied to lime-stones of very different formations. The lias lime-stone is of a dark blueish-grey colour, and in the lower beds a whitish or yellowish-grey; it varies much in its quality, some beds containing a large portion of silex and alumine, together with bituminous matter. The more compact varieties have a flat conchoidal or a slaty fracture. This formation is particularly interesting to the geologist and naturalist, on account of the remarkable organic remains in which it abounds. The lias lime-stone extends from Lyme in Dorsetshire, where there is a remarkably fine section on the sea-coast, to Whitby in Yorkshire.

The yellow oolitic lime-stone or roe-stone that covers the lias has been referred to under oviform or globular lime-stone; but the small globules which it contains are not an essential part of this lime-stone, they may be regarded as an accidental mode; for many beds in this formation scarcely present any appearance of oolitic concretions. This lime-stone varies from nearly compact to earthy, and in some situations presents indications of a crystalline structure. Portland-stone, of which St. Paul's and most of the public buildings in London are constructed, is an oolite lime-stone procured from the Isle of

Portland. This stone occurs in the uppermost part of the oolite formation. The globules are too minute to be distinctly perceived without a glass.

EARTHY LIME-STONE. — The varieties of earthy lime-stone differ in colour, degrees of cohesion, and in purity; the principal and most remarkable of these varieties is chalk.

CHALK is too well known to English readers to require any detailed description of its characters. The colour is white or yellowish-white; it is dull and opaque; the fracture is earthy; the softer kinds yield to the nail, and leave a mark when drawn over other substances. Its specific gravity is about 2.50. Some beds of chalk consist almost entirely of pure carbonate of lime; others contain a portion of silex, alumine, or magnesia. Chalk may be divided into two kinds, soft chalk and hard chalk; the first forms the upper, and the latter the lower beds of chalk, which are so extensively spread over the south-eastern parts of England.

The whole series of chalk strata is called by geologists the chalk formation; part of this series covers a considerable portion of the southern and eastern counties of England; its most northern termination is the promontory of Flamborough-Head in Yorkshire. A detached portion of this series occurs as far west as Beer in Devonshire, forming a range of rocks extending into the sea, and intersected by subterranean passages and caverns. The upper part of the chalk formation is composed principally of soft chalk, irregularly stratified, and abounds in nodules of flints generally arranged horizontally; sometimes the flint forms irregular strata, and sometimes runs in slender veins through the chalk, as may be distinctly seen in the cliffs near Ramsgate. The soft or upper chalk abounds in petrifactions or extraneous fossils, particularly in echinites. The lower chalk appears in some situations distinctly stratified; some of the beds are sufficiently hard to be used for building-stone. This part of the chalk formation is particularly well displayed near Dorking in Surrey, and may be examined to advantage in the numerous quarries in that neighbourhood. It contains fewer flints and organic remains than the upper chalk; radiated pyrites in globular and elongated concretions are common in these beds. The greatest thickness of the upper chalk strata is estimated at about 200 feet, and of the lower or hard chalk from 300 to 400 feet.

CHALK-MARLE and MARLE. — Beneath the chalk there occurs in various situations an impure calcareous marle, called chalk-marle or grey-chalk. This marle, the greatest thickness of which has been estimated at 300 feet, sometimes nearly resembles the soft chalk in the upper beds; in other situations, it passes by gradation into grey sand or clay.

Marle can scarcely be classed with simple minerals, as it consists of a mixture of calcareous, siliceous, or aluminous earth, and will be noticed among earthy compounds.

AGARIC MINERAL, *Chaux Carbonatée Spongieuse*, Haüy, is a white and friable deposition of calcareous earth, found in the fissures or covering the surface of lime-stone. This deposition has a similar formation to calcareous tufa, but the particles are fine and loosely adhering; it occurs in the fissures of oolite lime-stone in Gloucestershire and Oxfordshire.

APHRITE, *Schaumede*, Werner, *Silvery-Chalk*, Kerwan, is composed of scales or laminæ, forming small masses or incrustations in the fissures, or on the surface of lime-stone strata, in some parts of Hessia and Thuringia. The scales are white and pearly or silvery; they are loosely adhering and soft, soiling the fingers; it sometimes occurs in thin flexible plates. Aphrite effervesces violently in acids. Its constituent parts are — Lime 51.5, Carbonic Acid 39, Silex 5.7, Iron 3.3, Water 1. Bucholz.

TABULAR SPAR is a mixture of silex and lime, found massive, and in four-sided tables, in one mine in the Bannat of Temeswar. Its prevailing colour is greyish-white, the lustre shining and pearly. The structure imperfectly lamellar. It yields to the knife; it effervesces, and then falls into grains in nitric acid. It contains — Silex 50, Lime 45, Water 5.

Sp. 57. MAGNESIAN LIME-STONE, or DOLOMITE.

1. *Crystallized, or Rhomb Spar.*
   Pearl Spar.
2. *Massive Dolomite.*
3. *Common Magnesian Lime-stone.*

Many rocks and strata formerly classed as varieties of lime-stone contain a very large portion of magnesia as a constituent part; it was for some time supposed, that magnesian lime-stone was confined to that class of rocks denominated primary; it is now, however, discovered, that magnesia occurs in a great number of lime-stone rocks that are considered of more recent formation, and even in many rocks of chalk. Magnesian lime-stone not only forms extensive strata and rocks of considerable magnitude, but it occurs in various situations in strata, alternating with common lime-stone. The proportion of magnesia is sometimes equal to that of the lime; more frequently it forms about two-fifths of the mass, and in chalk it rarely exists in a greater proportion than one-tenth.

Magnesian lime-stone does not possess any well-marked invariable physical characters that distinguish it from common lime-stone; it is by chemical tests only that we can certainly ascertain the presence of magnesia.

The magnesian lime-stones in alpine districts, and in the upper stratified rocks, differ from each other in the same manner as the common lime-stone, in these different situations. Magnesian lime-stone may therefore be arranged in three divisions; crystallized, finely granular, and common magnesian lime-stone.

CRYSTALLIZED DOLOMITE, *Chaux Carbonatée Magnesifere*, Haüy, DOLOMITE SPAR, RHOMB SPAR, BITTER SPAR, MIEMITE, BROWN SPAR, PEARL SPAR. — These different names have been given to varieties of crystallized dolomite, by different mineralogists.

Dolomite spar, rhomb spar, or bitter spar, occurs amorphous, and in rhomboidal crystals, like calcareous spar, and which have a similar cleavage, parallel to the faces of the rhomb; but the angles formed by the incidence of the planes vary a little from those of calcareous spar, being 106° 15′ and 73° 45′. The specific gravity is 2.89; it is harder than calcareous spar. Rhomb-spar from the Tyrol, contained Carbonate of Lime 68, Carbonate of Magnesia 25.50, Carbonate of Iron 1, Water and Clay intermixed 4. Klaproth. — Dr. Murray found in this mineral from Galloway — Carbonate of Lime 56, Carbonate of Magnesia 42. It occurs in compact dolomite and imbedded in chlorite-slate in some parts of Scotland, and is found in various other rocks and in beds. With the exception of hardness and specific gravity, its other characters resemble those of calcareous spar. Dolomite spar occurs sometimes in prismatic concretions.

Miemite is a green or greenish-white variety of dolomite spar, found at Miemo in Tuscany, imbedded in gypsum; it contains—Carbonate of Lime 53, Carbonate of Magnesia 42.50, Carbonate of Iron 3.

Brown-spar, or pearl-spar, is distinguished by its pearly lustre, which is of different degrees of intensity, from shining to glimmering; its colours are white or pearl-grey, but sometimes reddish or brown; by exposure to the atmosphere it becomes brown and almost black, on which account it was called brown-spar by Werner; it is more or less translucent.

Brown-spar occurs in small crystals and amorphous; the crystals are rhombs, but are frequently curved or lenticular and densely aggregated, and often cover the surface of other crystals. It occurs also in globular, lamellar, or reniform masses, and is sometimes fibrous.

Pearl-spar or brown-spar sometimes contains so large a portion of iron and manganese as to make it uncertain whether it should not be classed with sparry iron-ore.

Brown-spar is generally found in metallic veins; it occurs plentifully in the lead-mines of Durham and Northumberland. Brown-spar becomes brown or black before the blow-pipe. It effervesces with acids; it always contains carbonate of iron and manganese in variable proportions, united to carbonate of lime and magnesia.

Massive Dolomite resembles fine granular lime-stone or common statuary marble; it forms beds of vast size in many alpine districts, particularly at St. Gothard; it occurs also in various parts of the Appenines, and forms entire mountains in Carinthia. It has been found in the Isle of Iona; its colours are generally white or greyish-white; the structure is finely granular, the grains are generally more loosely adhering than in statuary marble, and are easily separated by the finger; but some varieties possess greater hardness. A variety of dolomite in the Isle of Tenedos, was used by the ancient sculptors. According to Professor Cleaveland, dolomite occurs in Connecticut resembling loaf-sugar, but so friable that it crumbles between the fingers; this dolomite dissolves rapidly with effervescence in acids. In general, dolomite is more slowly acted upon by acids than granular lime-stone; but this will not always serve to distinguish them. The minuteness of the grains in dolomite prevents their laminar structure from being seen without a lens. Dolomite generally yields a reddish light when scraped with a knife, or placed on a hot iron.

The specific gravity varies from 2.73 to 2.86.

The Carinthian dolomite contains — Carbonate of Lime 52, Carbonate of Magnesia 48; that from St. Gothard — Carbonate of Lime 52, of Magnesia 46, Oxide of Iron and Manganese 0.75; from Tenedos — Carbonate of Lime 51, of Magnesia 48.

There is a variety of dolomite which is flexible when cut into long slabs. Dolomite is often intermixed with tremolite and talc; it frequently contains grains of yellow iron pyrites, arranged in thin seams. This mineral was called dolomite in honour of the French geologist Dolomieu.

Common Magnesian Lime-stone has no well-marked physical characters that will invariably distinguish all the varieties from common lime-stone. It has frequently a reddish-brown colour, and more or less of a sparry or crystalline structure, and is generally harder and less easily acted upon by acids than common lime-stone; but some varieties are a light yellowish-grey, and are compact or earthy, and effervesce as briskly with acids as common lime-stone.

The magnesian lime-stone in some of the quarries near Sunderland yields a fœtid odour when struck with a hammer; it is in fact a swine-stone. In other quarries the lime-stone does not possess this property.

Magnesian lime-stone, when burned, retains its causticity longer than common lime-stone, and is hence more efficacious in agriculture, when employed to decompose roots or vegetable matter on land recently brought under cultivation. The prevailing opinion is quite erroneous that magnesian lime-stone is injurious in agriculture; indeed it requires to be more sparingly used; hence it is far more valuable than common lime-stone, where it is to be conveyed to a distance, as a smaller quantity will suffice. The composition of magnesian lime is variable, containing from 25 to about 40 parts of carbonate of magnesia, combined with carbonate of lime and a small portion of silex, alumine, and oxide of iron and manganese. To the latter, the tint of purple observable in brown magnesian lime-stone may be attributed. Chalk, which contains magnesia, is often dotted with black points, which are probably caused by manganese.*

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* Sulphuric acid separates lime from magnesia, forming, with the latter earth, a soluble salt, sulphate of magnesia, or Epsom salt. The entire separation of the earths is rather difficult, but for practical purposes the directions given in Dr. Henry's very valuable Elements of Chemistry are amply sufficient. But to detect speedily the presence of any notable portion of magnesia in lime-stone, let a small quantity of the stone be very finely powdered and added to diluted sulphuric acid in a tea-cup, and stirred until the effervescence ceases, and the solution has lost its acidity, which may be known by the taste; filter and decant the liquor into

Sp. 58. GYPSUM, or SULPHATE OF LIME.

Crystallized or Selenite.	*Granular and Compact Gypsum.*
Fibrous Gypsum.	

Gypsum, or Sulphate of Lime, is far less abundant in nature than carbonate of lime. It never forms the entire mass of mountains, or of very extensive strata, but generally occurs in irregular beds of limited extent, and is most frequent in red marle or sand-stone, in which formation it often accompanies rock-salt. The occurrence of the two powerful mineral acids, the sulphuric and muriatic, in the same situations, the one combined with lime, the other with soda, is an interesting fact in geology, for which no satisfactory solution has yet been offered. It seems probable that gypsum is not, in all instances at least, an original formation, but has been formed from beds of lime-stone by the access of sulphuric acid. The latter has probably been derived from the decomposition of iron pyrites, an opinion which may receive

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another cup, place it by the fire, and when hot, add a little sub-carbonate of soda or potash, an effervescence will take place at first, with the uncombined sulphuric acid; continue to add the alkali by degrees, the magnesia, if present in any considerable quantity, will form a copious white precipitate.

some confirmation from the quantity of the red oxide of iron in the red marle that accompanies gypsum.

CRYSTALLIZED GYPSUM, or SELENITE, sometimes accompanies compact gypsum, but is frequently found in detached crystals in beds of clay; it is colourless and transparent, or yellowish-white, yellow, and brown; the lustre is pearly and shining, or splendent.

The primitive form, according to Haüy, is a very low four-sided prism (Plate III. fig. 10.), the alternate angles of which are 113° 8′ and 65° 52′, and the proportion of the two sides of the base are to the height as 12 and 13 to 32. The secondary forms are most generally tabular; two of the more common forms are represented Plate III. figs. 10 and 11. The crystals are sometimes large; the structure is laminar, with three cleavages parallel to the faces of the primitive crystal; the cleavage is very distinct in the direction of the base, the laminæ are flexible but not elastic. Selenite also occurs in lenticular crystals, and sometimes the crystals are aggregated into groups of various forms. The specific gravity is about 2.30. It is much softer than calcareous spar, and may be scratched with the nail; it exfoliates before the blow-pipe, and melts into a white enamel. Selenite frequently occurs in the clay so abundant near London, hence called London clay.

Fibrous Gypsum is composed of parallel translucent fibres, which are either straight or waved; its colours are white, sometimes inclining to red. The fibres are acicular, and sometimes prismatic. The lustre is pearly, and either shining or glistening. The more translucent varieties are chatoyant. Fibrous gypsum accompanies compact and granular gypsum in various parts of the world. The most beautiful white and translucent fibrous gypsum occurs in thin strata in red marle at Clifton near Nottingham, and in other parts of that county. I have a specimen of red fibrous gypsum from Palestine, probably a member of the rock-salt formation, in that country denominated by St. Jerom, Lot's wife.

Fibrous gypsum is distinguished from satin spar by its inferior degree of hardness.

Granular and Compact Gypsum. — Massive gypsum, which occurs in beds or strata, has either a coarsely granular structure, which sometimes passes into laminated or a finely granular structure, passing sometimes into compact. It bears a great resemblance to granular lime-stone, but may be distinguished by its inferior hardness, as it yields to the nail; its specific gravity varies from 2.16 to 2.28.

Gypsum, whether granular or compact, is generally white, but is often veined with red; it is also sometimes red and yellow; it is more or less translucent. It falls into a powder by heat; at a greater heat it melts into a white enamel.

Gypsum disintegrates by the action of water into a white earthy and friable mass, and is called earthy gypsum; it occurs in masses or beds on the surface, and sometimes in the cavities of compact gypsum. The constituent parts of gypsum are — Lime 32.7, Sulphuric Acid 46.3, Water 21.

Gypsum rarely contains organic remains, which so commonly occur in lime-stone. There is, however, a formation of gypsum strata over chalk in the vicinity of Paris, in which the bones of unknown species of quadrupeds, and of birds and fresh-water shells, are very abundant. Introduction to Geology, p. 219.

Gypsum is sometimes employed in sculpture and architecture, under the name of alabaster; but, as it is soluble in about five hundred parts of water, it is unfitted to resist the action of the atmosphere in exposed situations. From some experiments made by Dr. Watson, late Bishop of Landaff, it appears that a mass of gypsum lost one-thirtieth part of its weight in two days, when suspended in water, which was changed several times.

When gypsum is calcined, it absorbs water rapidly, and solidifies, and is used for casts of statues, &c. and for plaster and stucco.*

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* In the United States of America, gypsum has been employed with the greatest advantage in agriculture, as a

SP. 59. ANHYDROUS GYPSUM, or ANHYDRITE.

Crystallized. | *Compact.*

ANHYDROUS GYPSUM, *Muriacite, Chaux Anhydro Sulphatée*, Haüy, differs so much in its composition, physical properties, and crystalline form, from common gypsum, that, agreeably to the principles we have adopted, we must consider it as a distinct species. The specific gravity of anhydrous gypsum is from 2.80 to 2.95. Its hardness is greater than that of calcareous spar. It does not exfoliate, like common gypsum, before the blow-pipe, but becomes glazed over the surface. It contains — Lime 40, Sulphuric Acid 60, without any water of crystallization. Anhydrous gypsum sometimes accompanies

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top-dressing. In England it has never been found very beneficial, though trials have been repeatedly made in various situations. I am informed by a gentleman long resident in North America, that the use of gypsum as a manure is limited to those parts of the United States that are situated at a distance of not less than about seventy miles from the coast. In the vicinity of the sea, its beneficial effects are not perceptible. Some sapient persons may feel disposed to doubt a fact for which no satisfactory explanation can at present be offered; but it may be sufficient to reply, that we are most profoundly ignorant respecting the operation of gypsum as a manure. The above fact may, perhaps, elucidate the cause of the failure of gypsum as a beneficial manure in England.

common gypsum, but it is of comparatively rare occurrence; it is found in some parts of Nottinghamshire, and some parts of the Continent of Europe, and might probably be discovered in many gypsum formations, were they attentively examined.

SPARRY ANHYDRITE or CUBE-SPAR, *Chaux Sulphatée Anhydre laminaire*, Haüy. — It occurs colourless and transparent, and also various shades of grey, red, yellow, and blue, and semi-transparent or translucent. The lustre is pearly and shining, or splendent. It is doubly refractive in a high degree. It occurs in laminated masses, and in four, six, or eight-sided prisms. The primitive form, according to Haüy, is a right rectangular prism, the proportion of the sides being to each other nearly as 16 to 13. Its structure is distinctly laminar, cleaving in the direction of the sides, and the diagonal of the prism. Its hardness and crystallization distinguish it from calcareous spar, and it does not effervesce with acids.

COMPACT ANHYDROUS GYPSUM is blueish-white or snow-white, and sometimes pale blue, grey, or red; it is translucent, and has a glistening or faint lustre. The fracture inclines to splintery or flat. It has been found massive in Nottinghamshire with common gypsum. It occurs mamillated and stalactitical, and in curiously contorted masses, called Pierre de Tripes, in the salt-mines of Wieliezka in Poland. There is a fibrous variety of anhydrous gypsum, of a red colour, at Halle in the Tyrol, and in Upper Austria. Anhydrous Gypsum also occurs radiated in the same situation, and in masses composed of small laminæ, or scales.

Sp. 60. ARRAGONITE.

Arragonite. — This mineral derives its name from the province of Arragon in Spain, where it was first discovered ; it might be classed as a variety of the carbonate of lime, were we to confine our attention to the constituent parts only, which are so similar to calcareous spar, that the first chemists in Europe were long unable to detect the difference. The crystalline structure of arragonite is, however, very different from that of calcareous spar, though the ablest crystallographers, Haüy and Bournon, are not agreed respecting the true primitive form of the crystal. Kirwan, in his Mineralogy, vol. i. p. 81. ventured to suggest that arragonite probably contained strontian; this conjecture appears verified by the analyses of Stomeyer, which have detected from 1.45 to 4.0 of that earth in this mineral. It is however difficult to conceive, that so small a portion of strontian could effect a change, both in the physical properties and crystalline structure of carbonate of lime.

Arragonite occurs regularly crystallized, and fibrous or capillary, and in globular or mamillated masses, and also coralloidal.

The specific gravity of arragonite is greater than that of calcareous spar, being 2.92; it is sometimes variable from the admixture of other substances. Arragonite is harder than fluor-spar; some varieties scratch glass feebly.* Arragonite cleaves with difficulty parallel to the lateral planes of a rhomboidal prism, the alternate angles of which, according to Bournon, are 117° and 63°; the cross fracture is uneven and vitreous. The Count de Bournon, who has devoted much time to the study of this species, says, the cleavage parallel to the terminal planes of the prism, cannot by any means be obtained: — " On ne peut en aucune maniere parvenir a cliver cette substance parallelment aux face terminal de ce meme prism." Mr. Jameson says, common arragonite has a fourfold cleavage, three of which are parallel to the axis, and the fourth to the terminal planes.

Crystallized Arragonite is transparent or translucent; it has a shining vitreous lustre, and is generally colourless; it is doubly refractive

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* I find this to be the case with the arragonite from the trap-rocks near Dumbarton in Scotland.

through oblique surfaces. Sometimes it has a slight tint of yellow or green; that from Arragon is spotted violet, or more frequently coloured with violet in the middle part of the crystal, and a few crystals are completely violet. The coralloidal arragonite has generally a snow-white colour, and is nearly opaque.

Arragonite dissolves with brisk effervescence in nitric acid. Before the blow-pipe it decrepitates strongly, and is reduced to caustic lime; by the mere heat of the candle, a small piece of arragonite becomes opaque, and separates into small splinters, or is made friable. The Spanish arragonite is highly phosphorescent when powdered and placed on a hot shovel; other varieties possess this property in a less degree. Its constituent parts are —

	Carb. of Lime.	Carb. of Strontian.	Water and Iron.	
	99.10	——	——	Vauquelin.
	99.50	——	0.50	Thenard.
Arragon	94.57	3.96	1	Stromeyer.
Arragon	94.82	4.08	with Mang. 1.70	Stromeyer.
Auvergne	97.69	2.07	Water 0.21	Stromeyer.

Arragonite occurs in prismatic crystals, which are aggregated and diverging, in the cavities of basalt in Dumbartonshire, mixed with prehnite and mesotype. It occurs also in basaltic rocks in Auvergne, and various parts of the world. In Arragon, where it was first noticed, it was discovered in red marle, and imbedded in gypsum, accompanied with reddish-brown crystals of quartz. Arragonite also occurs in veins accompanied with calcareous spar and ores of iron. The coralloidal arragonite is found in the lead-mines of Durham, and in the iron-mines of Styria and Carinthia.

Distinctive Characters. — Arragonite is distinguished from calcareous spar by its greater hardness, the difference of its crystalline structure, and by its becoming friable in the flame of a candle. Its specific gravity is much greater than that of mesotype; it is further distinguished from all zeolitic minerals by its infusibility.

SP. 61. FLUOR-SPAR, OR FLUATE OF LIME.

Crystallized Fluor.	*Compact Fluor.*
Massive Fluor.	*Chlorophane.*

FLUOR-SPAR, *Chaux Fluatée.* — This mineral never forms entire rocks or extensive strata, like some of the calcareous minerals before described, but it occurs principally in veins or in beds associated with metallic ores, and with quartz, calcareous spar, and heavy spar. It is found regularly crystallized, and in masses which have a crystalline structure, and, in some rare instances, it occurs compact. It has, also, occasionally been found in fossil organic remains.

The colours of fluor-spar are, violet-blue, emerald-green, yellow, and various; they are frequently clear and bright. It is transparent or translucent; the lustre vitreous, inclining to pearly, and of different degrees of intensity. The specific gravity varies from 3.10 to 3.20; its hardness is considerably greater than that of calcareous spar, but it will not scratch window glass; when placed on a hot iron, it emits a blue or greenish light. The blue varieties are ~~coloured~~ changed to red by heat. Fluor-spar is composed of — Lime 67.75, Fluoric Acid 32.25.

Crystallized Fluor most commonly occurs in cubes which are aggregated, and sometimes penetrate each other; the cubes are occasionally truncated or bevelled on the edges, or truncated on the angles. The regular octahedron is the primitive form; it occurs in some of the mines in Cornwall. The structure of fluor-spar is laminar, with a four-fold cleavage parallel to the faces of an octahedron and tetrahedron. The primitive form is easily obtained from the cube by mechanical division on the angles, as represented Plate II. figs. 1 and 2.

Beautiful large cubic crystals of fluor occur in the lead-mines in the county of Durham; they are generally violet or plum-blue, but some are of a bright emerald-green, and are splendent and transparent, rivalling the emerald in beauty, but not in permanence of colour or durability. White, yellow, and violet crystals, occur in Derbyshire, and in Devonshire and Cornwall.

Crystallized fluor occurs in almost every mining district in Europe. Rose-coloured octahedral crystals are found in the vicinity of Mont Blanc, and a variety called *chlorophane*, on account of the green light which it emits when heated, is found in Siberia, and at the mine of Pednandrae in Cornwall.

MASSIVE FLUOR is found in a mine near Castleton in Derbyshire, called the Blue-John mine. It occurs in large nodules or kidney-shaped masses, which have a confusedly diverging crystalline structure, and the colours, which are purple and yellowish-white, are arranged in concentric zones. It is cut into vases and other ornaments. The fluor lies in what is called a pipe vein, which traverses mountain lime-stone; the vein opens and contracts in various parts of its course. In some parts of the mine, there are spacious caverns beautifully encrusted with crystallizations and stalactites.

COMPACT FLUOR occurs in some of the northern parts of Europe, and at Pednandrae in Cornwall; it has an even or flat conchoidal fracture passing into splintery; it is harder than common fluor, and is translucent, but the lustre and colours are faint.

Disintegrated, or earthy fluor, occurs in small quantities with common fluor-spar in some of the mines of Durham and Cornwall. It is generally encrusting other minerals. It is earthy and friable.

Fluor-spar, where it is abundant, is sometimes used as a flux in reducing metallic ores.

Sp. 62. PHOSPHATE of LIME.

Crystallized Apatite. *Green Apatite, or Asparagus Stone.*	*Massive Apatite, or Phosphorite.*

Phosphate of Lime, though common in the animal kingdom, being a principal constituent part of bone, is rather a rare substance in the mineral kingdom. It most frequently occurs in small crystals in veins. Sometimes it is imbedded in rocks; and near Truxillo, in the province of Estremadura, in Spain, it forms entire beds and ranges of hills, intermixed with quartz. Apatite, in its purest state, is entirely composed of phosphate of lime, containing — Lime 53.75, Phosphoric Acid 46.25. Klaproth.

Crystallized Apatite occurs of various colours, as white, greenish-white, green, blue, and red. It is transparent, semi-transparent, or translucent, and has a splendent or shining lustre, between vitreous and resinous. Internally the lustre is glistening. The specific gravity is 3.17. Its hardness is inferior to fluor-spar, but greater than calcareous spar.

It occurs crystallized in regular six-sided prisms, which is the primitive form.* Sometimes the prisms are truncated on the edges or angles, and sometimes the prism is terminated by a six-sided pyramid, the apex of which is often truncated.

The faces of the crystals are sometimes very unequal. In the British Museum there is a magnificent group of crystals of apatite from near Petersburg, in which the planes of the primitive crystal are three inches in breadth in one direction. The truncating planes are well defined. The external part of the crystal is perfectly limpid. Internally it is a yellowish-green. There are also, in the same collection, dark-green hexagonal crystals, from Arendal, of considerable size.

The structure of apatite is indistinctly laminar, with cleavages parallel to the sides and base of the primitive hexagonal prism. The cross fracture is uneven, or small conchoidal. Common apatite, and green apatite, or asparagus-stone, sometimes occur amorphous and granular. Apatite is infusible by the blow-pipe, but generally phosphoresces by heat. It is observed by Haüy, that the crystals with pyramidal terminations do not phosphoresce; but those with flat terminations possess this property. Apatite

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* The sides of the base, according to Haüy, are to the height nearly as 10 to 7.

occurs in the fissures of granite at St. Michael's Mount in Cornwall; but the crystals are minute, and difficult to be discovered. It is disseminated in yellowish curvedly laminar talc, at Stenna Gwyn, and is found in other parts in Cornwall; and has recently been discovered near Bovey-Heathfield, in Devonshire. It is found in France, Spain, and various parts of Europe.

MASSIVE APATITE, *Chaux Phosphatée Terreuse,* has a granular or a curvedly laminar structure, and is sometimes fibrous, like satin spar. It also occurs earthy. The colour is yellowish or greenish, and sometimes reddish-white. It is opaque, and possesses little lustre. It is soft, and sometimes friable or pulverulent. It emits a greenish light when rubbed or placed on a hot iron. It consists of phosphate of lime, intermixed with a small portion of lime, silex, and fluoric and muriatic acids. It forms entire strata at Estremadura, alternating with quartz. It also occurs in stalactitical and mamillated masses, and encrusting other minerals.

SP. 63. DATHOLITE.

Botryolite.

DATHOLITE, *Chaux Boratée Silueuse.* — This mineral has hitherto only been discovered in

Norway. It is associated with prehnite, and bears a near resemblance to the laminar variety of that mineral. Its prevailing colours are greyish-white or milk-white. It is translucent or transparent, and has internally a shining lustre, between vitreous and resinous. It occurs crystallized in oblique four-sided prisms, which are generally truncated or bevelled, forming eight or ten lateral planes. The crystals are seldom large. It occurs also in granular concretions, which are densely aggregated, resembling, at first view, white foliated or granular lime-stone.

The cross-fracture of datholite is imperfectly conchoidal. The specific gravity, according to Klaproth, is 2.98. Its constituent parts are — Silex 36.5, Lime 34, Boracic Acid 24, Water 4. Datholite exfoliates by heat. It intumesces, and melts before the blow-pipe, and gelatinizes in acids.

Botryolite occurs in mamillated and botryoidal concretions, which have a lamellar concentric structure, and are composed of delicate, radiated, or diverging fibres. It consists of — Silex 36, Lime 39.50, Boracic Acid 13.50, Oxide of Iron 1, Water 0.50.

The colours of datholite and botryolite incline to greenish or greyish-white. They are more or less translucent; the former sometimes transparent. In their physical or chemical properties they resemble zeolitic minerals, with which they ought probably to be classed. If we substitute alumine for boracic acid, we may observe that the composition would be the same as prehnite.

Sp. 64. CRYOLITE.

This rare mineral has been found only in Greenland. It occurs in lamellar masses, forming thin layers in gneiss. Its constituent parts would induce us to class it with saline minerals, but it is insoluble in water. It has a greyish or brownish-white colour, a glistening lustre between pearly and vitreous, and is translucent. It has a three-fold rectangular cleavage; two of the cleavages are very distinct. Cryolite is softer than fluor-spar. It melts in the flame of a candle. When exposed to the blow-pipe it melts, and afterwards hardens and assumes the appearance of a slagg. Its constituent parts are — Alumine 24, Soda 36, Fluoric Acid and Water 40. (Thompson's Annals, vol. ii. p. 389.)

Sp. 65. MAGNESIA, NATIVE.

Magnesia has rarely been discovered pure in the mineral kingdom. It was found at Hoboken, in New Jersey, in veins from a few lines to two inches in thickness, that traverse a rock of serpentine in various directions. It has a distinctly laminar or broadly fibrous structure; the laminæ radiate from a centre, and are slightly elastic and transparent. The lustre is shining and pearly. By exposure to the weather, the surface becomes dull and opaque. It is soft and soluble in mineral acids. It contains 70 parts pure Magnesia, 30 of Water.

SP. 66. MAGNESITE.

Magnesite is a native carbonate of magnesia. It has generally a yellowish-white colour. It is opaque and dull. It occurs amorphous, and in tuberose masses, and spongiform. It is often dotted or marked with dendritical delineations. It has been found in serpentine in Moravia, Styria, and Italy. It is harder than calcareous spar. The fracture is flat conchoidal or splintery. The specific gravity is 2.88. It hardens before the blow-pipe, and dissolves slowly in mineral acids. One analysis by Bucholz gives — Magnesia 48, Carbonic Acid 52. In other analyses, there were — 92 Carbonate of Magnesia, with a small portion of Silex, and other ingredients. Magnesite is found in some situations, with a larger portion of silex, particularly in Piedmont, where it is employed in the manufacture of porcelain.

MEERSCHAUM. See EARTHY COMPOUNDS, Appendix.

SP. 67. BORACITE.

This mineral, which is principally composed of magnesia, lime, and boracic acid, has hitherto only been found at Lunenburg in Hanover, and near Kiel in Holstein. It occurs imbedded in gypsum, in small cubic crystals, which are sometimes truncated on the edges and angles. The colours are grey, or greenish or yellowish-white. It is transparent or translucent. The internal lustre is shining or splendent, inclining to vitreous. The structure is laminar; and the cleavages parallel to the faces of the cube. It scratches glass feebly. The specific gravity varies from 2.56 to 2.94. It is fusible with ebullition into a yellowish enamel. According to Vauquelin, it contains — Magnesia 16.6, Boracic Acid 83.4. Another variety, analysed by Westrumb, gave — Magnesia 11, Lime 13.50, Alumine 1, Silex 2, Oxide of Iron 0.75, Boracic Acid 68. The cubic crystals that are truncated have the angles opposite to each diagonal dissimilar. (See Plate III. fig. 9.) Boracite becomes electric by heat, and the opposite dissimilar angles are in different states, the one being positive, the other negatively electric.

Sp. 68. SULPHATE of BARYTES, or HEAVY-SPAR.

- *Crystallized,*
- *Crested,*
- *Columnar,*
- *Radiated,*
- *Granular, and*
- *Fœtid Sulphate of Barytes.*

The earth called barytes derives its name from the Greek word *baros*, heavy. The two species which are composed of this earth are the heaviest of all minerals that are not metallic, except zircon. Fortunately barytic earth is not abundant in nature, for were it as universally distributed as silex, alumine, or lime, it would be incompatible with the existence of land animals on our planet, as it is a most deadly poison. Barytic earth is either combined with sulphuric or carbonic acid, and generally occurs in veins with metallic ores. It also enters into the composition of a few earthy minerals, but in a very small proportion.

Sulphate of Barytes, or Heavy-Spar, *Baryte Sulfatée*, occurs generally in veins, and is either crystallized, lamellar, fibrous, granular, compact, or earthy. The prevailing colours are greyish or yellowish-white and red; sometimes the colours incline to blue. Crystallized sulphate of barytes is frequently colourless and transparent. The specific gravity varies from 4.30 to 4.47. It is softer than fluor-spar. Before the blow-pipe it decrepitates, and melts into a white enamel. When a fragment has been exposed to the blow-pipe, it gives the flavour of sulphuretted hydrogen, or putrid eggs, if laid on the tongue.

CRYSTALLIZED SULPHATE OF BARYTES, *Lamellar Heavy-Spar*, (Jameson,) has a laminar structure and cleavages parallel to the sides of a rhomboidal prism, which is the primitive form. (Plate III. fig. 23.) The obtuse angles formed by the incidence of the plane M on M is 101° 32′, and the angle of P with M, 90°; the length of the base is to the height as 45 to 46. The cleavage is most distinct in the direction parallel to the face P, or the base of the prism. The secondary crystals are generally flat prisms or tables, as represented in Plate III. figs. 24, 25, 26. The crystals are frequently transparent, and have a shining vitreous lustre, inclining to pearly. They often occur of considerable size, and very well defined. Very fine crystals of sulphate of barytes are found in the mines of Durham and Cumberland.

Crystallized sulphate of barytes when pure contains—Barytes 67, Sulphuric Acid 33. Some varieties contain a portion of silex. Curved lamellar sulphate of barytes occurs in amorphous masses, and also globular or reniform. The curved lamellæ are sometimes arranged like the petals of a flower, uniting at a point. This variety is not uncommon in the mines of Derbyshire.

Crested Sulphate of Barytes consists of an aggregation of lamellæ, with rounded or indented edges.

Columnar Sulphate of Barytes is composed of an aggregation of slender prisms, adhering and forming thicker concretions, or imperfect prisms or columns, which are deeply striated longitudinally. The colour is white, or yellowish-white. It is translucent, and has a pearly lustre.

Radiated Sulphate of Barytes, *Bolognian-Stone*, generally occurs in globular or roundish masses, which are rough externally; when broken the structure is fibrous, consisting of slender or broad fibres, diverging from a centre. It is found at Monte Paterno, near Bologna, in Italy, imbedded in argillaceous marle.*

Granular Sulphate of Barytes occurs in masses composed of small grains, which have a laminar structure. It nearly resembles granular carbonate of lime, but is distinguished by its greater specific gravity.

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* This variety possesses the property, in a remarkable degree, of becoming luminous when calcined and exposed to the sun, or a clear sky, and carried into a dark room.

Sulphate of barytes occurs also nearly compact, and sometimes in coarse earthy particles, which are loosely cohering.

FŒTID SULPHATE OF BARYTES, or HEPATITE, occurs in globular masses, which have a laminar, or a radiated structure. It differs from the preceding varieties, by yielding a fœtid odour when rubbed or heated. It contains from 2 to 6 parts of Sulphate of Lime, with a small portion of Carbonaceous Matter and Sulphur, and about 90 parts Sulphate of Barytes. It has been found near Buxton in Derbyshire.

ESSENTIAL CHARACTERS OF ALL THE VARIETIES OF SULPHATE OF BARYTES.

Specific Gravity considerably exceeding 4.

Hardness inferior to fluor-spar.

Insoluble in all the acids.

Fusible by the blow-pipe, and affects the tongue with a disagreeable flavour after being heated.

Distinctive Characters.—Its insolubility in heated acids distinguish it from the carbonate of barytes, or of strontian. It does not yield a metallic globule by the blowpipe, like carbonate of lead, and many metallic minerals. It is heavier than sulphate of strontian, and does not give a rose-colour to flame when powdered, like the latter mineral. From all the varieties of carbonate or sulphate of lime, it is distinguished by its greater specific gravity.

Sulphate of barytes occurs in veins in the various mining districts of England and Wales, particularly in Derbyshire, Durham, Cumberland, and Westmoreland. The finest crystallizations of this mineral are obtained from the mines in the latter counties. It has also been found in amorphous crystalline masses, in a bed of fullers'-earth, at Nutfield, near Riegate, in Surrey.

SP. 69. CARBONATE OF BARYTES, OR WITHERITE.

CARBONATE OF BARYTES. — This mineral is less frequent in mines than the sulphate of barytes. It is rarely crystallized, but most frequently occurs in detached masses, which are sometimes rounded, and have a striated or diverging flatly fibrous structure. It is highly translucent, and has generally a yellowish-white or brownish-white colour. It has a glistening lustre, inclining to resinous. The specific gravity is about 4.30. Its hardness is inferior to fluor-spar. Before the blow-pipe, it melts into a white enamel. It dissolves with effervescence in heated and diluted muriatic or nitric acid. The constituent parts are — Barytes 78, Carbonic Acid 22.

CRYSTALLIZED CARBONATE OF BARYTES. — The primitive form, according to Haüy, is an obtuse rhomboid, the incidence of the planes forming angles of 88° 6′ and 91° 54′. The secondary crystals are commonly six-sided prisms, terminated by six-sided pyramids, with the terminal edges and summits truncated. The crystals are seldom large, like those of sulphate of barytes.

Carbonate of barytes appears to be a scarce mineral on the continent of Europe. It occurs in considerable quantities in some of the lead-mines on the north-western part of Yorkshire, and in the adjoining mines of Westmoreland and Durham. The veins in which it is found sometimes traverse alternating strata of mountain lime-stone and sand-stone; and in some situations it has been observed, that in the sand-stone the matrix of the vein is sulphate of barytes; but when the vein enters the lime-stone, it is carbonate of barytes. The mine at Anglesark, in Lancashire, where it was first obtained, has ceased to be worked.

Sp. 70. SULPHATE of STRONTIAN, or CELESTINE.

This mineral is seldom found in metallic veins. Its principal repositories are red marle, or sand-stone; and it is often associated with gypsum. Sulphate of strontian occurs crystallized and in masses, which are either fibrous, laminar, granular, or compact. The prevailing colour is white to blue. It is translucent or transparent, and has a shining pearly lustre. It refracts doubly. The specific gravity varies from 3.60 to 3.90. Sulphate of strontian is softer than fluor-spar. Before the blow-pipe, it melts into a white friable enamel; but its most remarkable character is the rose-red colour which its powder communicates to flame.* This property is possessed by both the sulphate and carbonate of strontian, and serves to distinguish them from carbonate or sulphate of barytes, and every other earthy mineral. Pure sulphate of strontian is composed of — Strontian 54, Sulphuric Acid 46, Vauquelin : — or, Strontian 58, Sulphuric Acid 42, Klaproth.

CRYSTALLIZED STRONTIAN. — The primitive form is a right rhomboidal prism, the alternate angles of which are 104° 48′ and 75° 12′. The length of the base is to the height as 114 to 113. (Plate III. fig. 27.) The secondary forms nearly resemble those of sulphate of barytes, with a slight difference in the admeasurement of the angles. The crystals are more frequently prismatic than tabular. Plate III. fig. 28. represents one of the crystals (*epointée*). Haüy

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* Let a little spirits of wine be inflamed, and the powder added by degrees, the red colour will be very perceptible. Barytes yields a yellow flame by the same process.

has enumerated seven secondary forms. The finest crystals come from the Valley of Noto, and Mazzara, in Sicily. Sometimes the crystals are irregular and aggregated into masses.

FIBROUS SULPHATE OF STRONTIAN occurs in masses composed of slender prisms, which are either parallel or diverging. The cross fracture is indistinctly laminar.

LAMINAR, GRANULAR, and COMPACT SULPHATE OF STRONTIAN. — Sulphate of strontian occurs in masses, with a promiscuously laminar structure. When the laminæ are small, the structure appears granular, and the mass resembles coarsely granular lime-stone. It has been found near Berkley, in Gloucestershire, in long cylindrical forms, either straight or curved, which appear to have been derived from some species of zoophyte. The formation of these cylinders is probably similar to that of the spheroidal masses of sulphate of strontian found at Mont Martre, near Paris: the latter contains about 9 per cent. of carbonate of lime, and is sometimes nearly compact.

Sulphate of strontian is found in red sandstone, in Gloucestershire, Somersetshire, and Glamorganshire; and near Knaresborough, in Yorkshire; and in Hanover, Switzerland, Naples, Sicily, &c.

SP. 71. CARBONATE OF STRONTIAN.

CARBONATE OF STRONTIAN, *Strontian Carbonatée,* was first discovered in metallic veins, at Strontian in Argyleshire. It occurs massive and very rarely crystallized in slender six-sided prisms, terminated by low six-sided pyramids. The colours are pale yellowish-green or greenish-white; it is semitransparent or translucent; the lustre inclines to pearly, and is shining or glistening. The structure of the massive varieties is broadly radiated, or divergingly fibrous; the cross fracture is uneven. It is softer than fluor-spar, yielding easily to the knife. The specific gravity is 3.46. It is infusible before the blow-pipe, but tinges the flame red. It dissolves with effervescence in muriatic or nitric acid. The constituent parts are — Strontian 69.5, Carbonic Acid 30, Water 0.5. Klaproth.

The known localities of this mineral are few beside Strontian; it has been found at Braunsdorf in Saxony, and in Peru.

Distinctive Characters. — Its colour and solubility in acids distinguish it from sulphate of strontian. The rose-colour it communicates to flame, and its less degree of specific gravity, distinguish it from carbonate of barytes.

Sp. 72. GADOLINITE.

Orthite. | *Pyrorthite.*

This mineral was so called from Professor Gadolin, who first discovered the constituent ingredients. It is remarkable, as containing more than fifty parts in the hundred of the earth yttria.* It is further distinguished by its great specific gravity, which exceeds that of all earthy minerals, except zircon, corundum, and barytes.

The colours of gadolinite are velvet-black, or greenish or brownish-black. The lustre is resinous and shining; it is opaque, or faintly translucent on the edges. The specific gravity varies from 4.04 to 4.23. Some varieties decrepitate before the blow-pipe, and are difficultly fusible; other varieties intumesce and melt into an imperfect slagg. It forms a thick grey jelly when pulverised and digested in nitric acid.

Gadolinite occurs amorphous and disseminated, and more rarely crystallized in oblique four-sided prisms, and also in six-sided prisms.

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* Yttria is very ponderous, its specific gravity being 4.84; in many of its properties it resembles alumine, but it is not soluble in fixed alkalies, and is infusible.

The constituent parts are — Yttria 55.5, Silex 23, Oxide of Iron 16.5, Glucine 4.5. Ekeberg. Yttria 35, Silex 25.5, Oxide of Iron 25, Lime 2, Oxide of Manganese 2, Water and Volatile Matter 10.5. Vauquelin.

Gadolinite appears to be frequently intermixed with carbonaceous matter, and hence it sometimes scintillates before the blow-pipe. The minerals recently discovered, called orthite and pyrorthite, have a near resemblance to gadolinite, and occur with it in the neighbourhood of Fahlun and the mine at Finbo. They are regarded as varieties of the latter mineral. Pyrorthite contains so much combustible matter that it takes fire and burns for a few moments before the blow-pipe. Small imbedded specimens of these minerals have recently been placed in the collection of the British Museum. They have a brownish-black colour and a shining resinous lustre. According to an analysis of Berzelius, orthite is a very complex mineral, containing the following constituent parts: — Silex 32, Lime 7.84, Alumine 14.80, Protoxide of Cerium 19.50, Protoxide of Iron 12.44, Protoxide of Manganese 3.44, Yttria 3.44, Water 5.36.

Yttria is found in combination with tantalum and cerium, and has recently been discovered by Berzelius, combined with fluoric acid and silex. The specimens hitherto received in this country are too minute to be described by their mineral characters. In one variety of fluate of yttria, Professor Berzelius has discovered the fluate of a new earth, which is named thoria or thorina.

APPENDIX

TO

BOOK II.

EARTHY COMPOUNDS.

Rocks or Minerals composed of an indefinite admixture of Earths, or of simple Minerals intimately united.

BASALT. — When exposed to the atmosphere or the action of water, this rock is generally covered with a brown or reddish incrustation; but its colour internally is greyish or greenish-black, more or less intense. It is dull and opaque. Its texture is fine-grained, approaching to compact; but on examination with a lens, it will be seen that basalt is composed of minute grains or crystals intimately united. The compact varieties pass into clink-stone, the granular varieties into greenstone. Basalt breaks with difficulty; its hardness is variable, but it yields to the knife. Its specific gravity is about 3. It melts before the blow-pipe into a black glass. The analysis of basalt by Klaproth gives — Silex 44.50, Alumine 16.75, Lime 9.50, Magnesia 2.25, Soda 2.60, Oxide of Iron 20, Oxide Manganese 0.12, Water 2.

Basalt forms beds and mountain masses, and large veins intersecting other rocks. It is frequently columnar.

The columns vary in size, from a few inches, to 30 or 40 feet in length; they are sometimes two feet or more in breadth. Basalt also occurs in tabular or in globular masses, the latter are formed of concentric layers; it is sometimes vesicular, and the cavities are often partly filled by zeolites and calcareous spar. In its constituent parts and appearance, it nearly resembles dark compact lava, and is supposed by many geologists, to have been formed by fire; a supposition which derives additional confirmation, from the effects produced by it, where it is found in contact with other rocks.

Basalt was formerly supposed to be composed of hornblende, felspar, and iron-clay, but the Count de Bournon says he could never discover common hornblende in the basalt of Scotland; and, according to the examination of Cordier, basalt and dark-coloured lava are composed principally of grains of augite, iron-sand, and felspar.

EURITE, or WHITE-STONE.—This rock forms a considerable part of the north-western side of the Saxon Erzebirge. It there incloses large beds and masses of granite, into which rock it passes. Eurite is principally composed either of granular or compact felspar, and may be regarded as a granite, abounding almost exclusively with felspar, and passing into porphyry. Granular eurite resembles the white elvan of Cornwall*, containing crystals of felspar imbedded in greyish-white granular felspar, with occasionally a

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* The white elvan or porphyry of Cornwall I consider as the same in fact with Werner's white-stone: it is only a varied form of granite.

little mica and quartz. The very small-grained light-grey granite, or grey porphyry of Arran, is a variety of white-stone. The compact varieties of eurite being composed of compact felspar, pass into clink-stone and clink-stone porphyry.

CLINK-STONE, PHONOLITE, PORPHYRY-SLATE, occurs in beds of considerable magnitude among basaltic rocks, called by some geologists the trap formation. It is sometimes columnar, but frequently it has a thick slaty structure; the fracture in this direction has a glistening lustre, the cross fracture is dull. When thin plates of this mineral are struck they give a metallic sound. The colour is generally greenish-grey; it is translucent on the edges. Clink-stone yields to the knife, and is easily frangible. Before the blow-pipe, it melts into a grey-coloured glass. The specific gravity is about 2.80. Clink-stone is frequently porphyritic, containing distinct crystals of felspar. This rock ought, perhaps, to be regarded as a more compact basalt, abounding in felspar, in which the constituent parts have become intimately united by a partial fusion. According to Klaproth, it contains — Silex 57, Alumine 24, Lime 3, Soda 8, Oxide of Iron and Manganese 0.25, Water 3.

Clink-stone is common in many parts of the south of Scotland. It occurs also in Cumberland and Westmoreland. Magnificent ranges of columnar clink-stone are displayed in a deep ravine in Swarth-fell, on Ulswater Lake, opposite the seat of J. Marshall, Esq.

CLAY-STONE.—This rock appears to pass by intermediate gradations from compact felspar to indurated clay. It forms beds among basaltic rocks, and also in clay-slate. The colours are blueish and yellowish-grey, or yellowish-white and brownish-red; it is sometimes spotted or striped; it has an earthy fracture, and is dull and opaque; the specific gravity is about 2.20; but that of the dark-coloured varieties is greater. It forms the basis of some porphyries. It occurs near Edinburgh, and in Radnorshire and Shropshire. The hardness of this rock is very variable, but all the varieties yield to the knife.

WACKE frequently accompanies basalt, and is probably only an earthy variety of that rock, containing a large portion of green-earth. It occurs forming irregular beds and mountain masses, which are frequently vesicular. When the cavities contain nodules of agate, &c. it becomes amygdaloid. The prevailing colour is greenish-grey; it is dull, earthy, and opaque; it may be scraped with a knife, and feels rather greasy. The specific gravity is various, from 2.60 to 2.90: it melts before the blow-pipe into a greenish slagg. It would be useless to give the analysis of a mineral evidently composed of different species. The prevailing ingredients are silex, alumine, and iron. The wacke at Calton-Hill, near Edinburgh, contains imbedded crystals of augite.

BASALT TUFF, or TRAP TUFF, consists of fragments of basaltic rocks, cemented by clay which is supposed to be formed from decomposed basalt or wacke.

If we regard basalt to be of igneous origin, like compact lava, wacke would appear to be formed by eruptions of earth and water, in the form of mud, similar to the eruptions from the volcanoes in the Andes. It is the opinion of Von Buch and other geologists, that many mountains of clink-stone, or porphyritic compact felspar, and also other rocks classed by Werner with trap-rocks, have never flowed in currents like lava, but have been partially melted or softened by the extensive agency of subterranean fire in their original position, and were bent and elevated by the same cause.

SERPENTINE is classed by some mineralogists as a simple mineral, but the very great variation in the composition of different rocks called serpentine, proves that it is an indefinite earthy compound.

The prevailing colour of this rock is green of various shades, which are frequently intermixed, forming spots and veins and clouded stripes. It also occurs reddish-brown and deep-red; it is nearly opaque, but a variety called noble serpentine, possesses a considerable degree of translucency; the lustre is faintly glimmering, but it frequently contains shining particles of quartz or other minerals. The hardness of serpentine is variable: it generally scratches calcareous spar. Some varieties, which are much intermixed with quartz, and contain a large portion of silex, yield with difficulty to the knife; other varieties, which probably contain a large portion of talc, are sectile. When pulverized, the powder is soft and rather unctuous. Serpentine breaks with difficulty, and the fracture is splintery or uneven, but in some of the translucent varieties approaches to conchoidal. Serpentine cannot properly be said to have any structure, as it is never found crystallized; its texture is nearly compact. The specific gravity varies from 2.2 to 2.57; it is infusible before the blow-pipe. Serpentine is most probably an intimate intermixture of hornblende and talc, or of hornblende and magnesia. Its prevailing constituent ingredients are silex and magnesia. Some analyses give — Silex 31, Magnesia 47, Alumine 3, Lime 0.50, Iron 5.50, Oxide of Manganese 1.50, Water 10. Other analyses give — Silex from 28 to 42, Magnesia 8 to 40, Iron from 2 to 43. It is evident, therefore, that serpentine cannot be regarded as a simple mineral.

Serpentine occurs in irregular beds or masses of considerable magnitude, forming entire rocks. It is often associated with white granular lime-stone, and when intermixed with it, forms the marble called *verde antique.* Some varieties of serpentine take a high polish, and are employed in ornamental architecture. Serpentine occurs at the Lizard in Cornwall, and in Anglesea. By a greater admixture of talc, serpentine passes into a soft and very sectile stone, called pot-stone.

NOBLE SERPENTINE differs from common serpentine in being translucent; they occur together and pass into each other.

POT-STONE, *Talc Ollaire Serpentine*, has, like most serpentines, a green colour; it is translucent, and the lustre is glistening; it is soft and sectile, and feels unctuous, and possesses sufficient tenacity to allow it to be turned in a lathe; hence, in some countries, it has been formed into culinary vessels, which resist the action of fire.

STEATITE and SOAP-STONE. — Steatite and soap-stone are probably only pot-stone or serpentine in a less indurated state. Steatite generally occurs massive, forming veins in serpentine; sometimes it occurs in metalliferous veins in other rocks. It is also found in amorphous masses imbedded in basaltic rocks. The colours are pale grey, yellow, or red; it is dull and translucent. Steatite feels unctuous to the touch, yields to the nail, and is sectile, cutting with a smooth shining surface. The specific gravity varies from 2.30 to 2.60. Its constituent parts are — Silex 59.50, Magnesia 30.50, Iron 2.50, Water 5.10. Steatite from Monte Ramuzzo yields — Silex 44, Magnesia 44, Alumine 2, Iron 7.30, Manganese 1.50, Chrome 2.00. Vauquelin.

Steatite is variable in its composition; the more indurated varieties are lamellar, and appear to pass into soft felspar; the more soft and earthy pass into porcelain clay. The most remarkable fact in the natural history of steatite is, that it sometimes contains imbedded crystals, which have the form of quartz crystals, or of calcareous spar, but they are composed of steatite. By what cause the quartz has been changed into steatite, or has been decomposed and removed, and the steatite has taken its place, we have yet to learn; nor will the fact ever be explained on the generally received notions respecting the inertness and repose of mineral substances in nature. This is only one of an extensive series of phenomena, which might convince every reflecting mind, that the chemistry of nature comprises the decomposition and transmutation of nearly all these substances, which are now regarded as elementary by the chemist, and these changes are constantly taking place in the mineral kingdom.

Soap-stone is milk-white or grey, and is so called from its resemblance in colour and feel to soap. It is sometimes spotted or striped with purple. It occurs in serpentine at the Lizard, and at the Cheese Wring in Cornwall, and is extensively used in the porcelain manufacture. Soap-stone contains — Silex 45, Magnesia 24.75, Alumine 9.25, Oxide of Iron 1, Potash 0.75, Water 8. Klaproth.

MEERSCHAUM contains nearly the same constituent parts as soap-stone, and is properly a very soft variety of that mineral; it occurs massive in veins that traverse serpentine, and is found near Bursa, and in other parts of Natolia, in beds immediately under the soil. Its colours are white, inclining to grey or yellowish-white; it is very soft and unctuous when first dug out of the earth; it lathers with water like soap, and is employed for washing by the Tartars. It is strongly adhesive, and has a fine earthy fracture. Its constituent parts are — Silex 41.50, Magnesia 18.25, Lime 0.50, Water and Carbonic Acid 39. Meerschaum is much used in Turkey in the manufacture of tobacco-pipes. It is found in small quantities in the serpentine of Cornwall.

FULLERS'-EARTH forms strata in the ferruginous sand below chalk in various parts of England, particularly near Wooburn in Bedfordshire, and at Nutfield near Riegate in Surrey. Its colour is a dull olive-green, inclining to brown or grey. It is unctuous to the touch, receives a polish from the nail, and falls into a soft pulp in water. Before the blow-pipe, it melts into a spongy slagg; its specific gravity is under 2. The constituent parts, as given by Klaproth, are — Silex 53, Alumine 10, Magnesia 1.25, Lime 0.50, Oxide of Iron 10, Water 24. An analysis of Bergmann gives — Silex 51, Alumine 25, Magnesia 0.7, Lime 3.3, Oxide of Iron 0.7, Water 15.5.

Fullers'-earth is found in various parts of Germany and Austria. The use of fullers'-earth for scouring cloth in the woollen manufacture was formerly very extensive in England; but it has a tendency to retard the felting of cloth, and injures its softness; hence its use is confined at present to the coarser kinds of woollen goods.

BOLE. — The term bole has been applied to many unctuous clays; the Wernerian mineralogists restrict the term to a yellowish or reddish unctuous earth found in basaltic rocks; it breaks down in water like fullers'-earth, and emits bubbles of air.

OBSERVATIONS ON SOFT EARTHY COMPOUNDS.

The following soft earthy compounds appear for the most part to be accidental admixtures of different earths, from the decomposition of rocks in the vicinity; they have been elevated to the rank of species by some mineralogists.

LEMNIAN-EARTH, *Sphragid*, Werner, is a yellowish-grey earth, procured in the Island of Lemnos; it falls into powder, like fullers'-earth, when immersed in water.

PIMELITE is a green earth in the veins and fissures of serpentine; it accompanies chrysoprase at Kosemutz in Silesia. Klaproth found in this earth 15 per cent. of oxide of nickel.

LITHOMARGE occurs lining the veins and fissures of porphyry and other rocks. The colours are white, red, and grey; it is soft and unctuous, yielding to the nail, and is strongly adhesive when applied to the tongue.

CIMOLITE, so called from the Island of Cimolin, where it was obtained, appears to be a greyish-white fullers'-earth, possessing the same properties, and is used for the same purposes.

MOUNTAIN-SOAP, YELLOW-EARTH, and KOLLYRITE — Certain admixtures of silex, alumine, magnesia, and colouring matter, have received the above names; but if every admixture of this kind were to be described as a distinct species, mineralogy would be burdened with as many names as there are rocks or districts, which yield a variety of coloured earth. — I shall proceed to notice some varieties of clay, which are employed for peculiar purposes in the arts.

CLAY. — The substance denominated clay is essentially composed of a variable proportion of siliceous and aluminous earth intermixed with sand; when it contains a considerable portion of calcareous earth, so as to effervesce with acids, it forms loam or marle. According to the greater or less prevalence of calcareous earth, the marle is denominated calcareous or aluminous marle. The characteristic property of clay is to become plastic, or kneadable with water. Where the quantity of sand is considerable, this property is diminished. The more plastic clays are suited for the use of the potter; but as clay is generally mixed with the oxide of iron, and becomes red or yellowish-brown when burned, it is only those varieties which are nearly free from metallic matter, that are employed for the finer kinds of pottery. When clay is much intermixed with sand, it is only suited for brick-clay. Siliceous earth is almost always the prevailing ingredient in common clay; an admixture of 20 per cent. of alumine, is sufficient to form a kneadable clay.

Clay occurs in beds of considerable thickness in alluvial districts, and is, in many instances, evidently formed from the materials of pre-existing rocks or strata, that have been disintegrated and washed down into valleys that were once lakes. Many extensive beds of clay appear to be original formations, or at least are as much so, as the strata with which they are associated.

PORCELAIN EARTH, or KAOLIN, is a soft or disintegrated felspar. (See FELSPAR.) Its colours are white of various tints; it is soft but not unctuous, and is but slightly adhesive. Its composition is variable; that of Limoges, according to Hassenfratz, contains — Silex 62, Alumine 19, Magnesia 12, Sulphate of Barytes 0.07. In the porcelain earth of Cornwall, Mr. Wedgewood found — Silex 20, Alumine 60, combined with Water. Kaolin is found in the vicinity of granitic districts.

POTTERS'-CLAY.—The purest kind is of a greyish-white colour, it is then called pipe-clay; the less pure kinds vary in colour from grey to brown. Pipe-clay occurs in beds of limited extent in Devonshire and Dorsetshire. Near Bovey-Heathfield there is a bed of pipe-clay fifty feet in thickness, resting on sand and gravel, and covered by broken strata or rubble. It is extremely plastic when moistened with water.

STOURBRIDGE-CLAY, FIRE-CLAY, or INDURATED-CLAY, forms strata alternating with dark argillaceous lime-stone; it also alternates with coal, generally forming the floor on which the coal rests. Its colours are grey or blueish-grey. It is sufficiently hard to resist the action of the nail when first dug out of the mine, but falls to pieces by exposure to air and moisture, and becomes plastic; it resists in a considerable degree the action of fire, and is used for fire-bricks to line furnaces, &c.

LOAM and MARLE are variable in their qualities, passing from friable to tenacious, and are either calcareous, effervescing strongly with acids, or contain but a very minute portion of calcareous earth, and scarcely effervesce. Loam forms the basis of fertile soils. Marle is frequently applied in the improvement of poor soils with the most beneficial effects. (See Introduction to Geology, 2d Edit. p. 248.)

SCHISTOSE, OR SLATE-ROCKS.

MICA-SLATE, or MICACEOUS SCHISTUS. — This rock, which has always a schistose or slaty structure, is essentially composed of mica and quartz; sometimes arranged in separate layers, and sometimes united. It has a shining silvery lustre, sometimes approaching to metallic. The colours are generally white or greenish-white or yellow; the latter colour is often caused by the decomposition of the mica. Mica-slate differs from gneiss, as it seldom contains felspar; gneiss passes into mica-slate, when the mica is abundant, and the felspar becomes scarcely apparent. When the constituent parts of mica-slate are intimately blended, it passes into shining clay-slate.

Mica-slate forms large beds or entire mountain masses, and generally rests on granite or gneiss.

QUARTZY MICA-SLATE. — In this variety the quartz and mica-slate form separate layers, and are generally indulated.

TALCY MICA-SLATE is softer than common mica-slate, the micaceous part approaching to the state of talc.

CLAY-SLATE, *Argillaceous Schistus*, when in its purest form, as in the finer kinds of roof-slate, appears homogeneous; its prevailing colours are blueish or greenish-grey, with a silky lustre. This rock has frequently a distinct slaty structure; sometimes it has two distinct cleavages meeting each other at an acute angle; but some clay-slate has a compact structure. Clay-slate yields to the knife; it is fusible into a black slagg. The composition of clay-slate is very variable. An analysis by Daubuisson gave — Silex 48, Alumine 23, Magnesia 1.6, Oxide of Iron 11.3, Oxide of Manganese 0.5, Potash 4.7, Carbon 0.3, Water 7.6. Some varieties contain a greater quantity of carbon. Clay-slate forms beds and entire mountains and mountain-chains of great extent and height, and it often alternates with hornblende-slate, chlorite-slate, talc-slate, and limestone, and is intersected by veins of quartz. Clay-slate and roof-slate occur in the alpine parts of England, Wales, and Scotland.

WHET-SLATE, NOVACULITE, or HONE,

is a very fine-grained or compact variety of clay-slate; it has a yellowish or greenish-grey colour; it is used for sharpening steel instruments. The best varieties of whet-slate come from Turkey.

ALUMINOUS SCHISTUS, ALUM-SHALE, or ALUM-SLATE, contains a large portion of carbonaceous or bituminous matter, intermixed with sulphuret of iron. It has a greyish-black colour, a glistening lustre, and a slaty structure, and splits by exposure to the air into thin plates; it is soft, yielding easily to the knife. From the quantity of carbonaceous matter which it contains, it continues to burn slowly when piled in heaps and set fire to. The sulphur absorbs oxygen and unites with the alumine during this process; the saline contents are subsequently extracted by solution in water. Alum-shale forms a bed of unknown thickness at Whitby in Yorkshire, which extends over a great part of the Cleaveland Hills, and is intersected by a vertical dyke of basalt. Many of the coal-shales or bituminous shales accompanying coal, would form alum by a similar process.

BITUMINOUS-SHALE is only a variety of black coal-shale, sometimes containing a sufficient quantity of bituminous matter to be burned as an inferior kind of coal.

GREY-WACKE and GREY-WACKE-SLATE, *Grau Wacké*, German, *Psammite* of some French geologists. — No two rocks appear more dissimilar than clay-slate and sand-stone (see SAND-STONE); yet they pass by gradual intermixture into each other, and in this transition, form all the varieties which have received the barbarous name of grey-wacke. Grey-wacke and grey-wacke-slate are composed of grains of quartz, and sometimes of mica disseminated in a base of clay-slate. When the grains of quartz increase in quantity and size, and are partly rounded, the grey-wacke approaches to the nature of pudding-stone, with a cement of clay-slate. When the stone contains but a small portion of the cement, grey-wacke passes into sand-stone. The French, under the generic name of *psammite*, class all the varieties both of grey-wacke and sand-stone. Grey-wacke and grey-wacke-slate form extensive beds and entire mountains, and sometimes alternate with lime-stone and sand-stone.

SAND-STONE.

SAND-STONE is composed of grains or particles of different minerals generally united by a cement. It may be divided into siliceous sand-stone, micaceous sand-stone, sand-stone with an argillaceous base, and calcareous sand-stone. Sand-stone is generally distinctly stratified; it often alternates with lime-stone, and forms hills of considerable magnitude.

SILICEOUS, or QUARTZY SAND-STONE, is almost entirely composed of grains of quartz, commonly united by a small quantity of cement, consisting of ferruginous clay. Sometimes the siliceous particles have no visible cement, and the sand-stone appears to be crystalline granular quartz, and is essentially the same as the quartz rock of the German geologists. Siliceous sand-stone varies in the coarseness of its grains; the coarser grained has received the name of mill-stone grit in the northern counties of England, from having been used for mill-stones. The finer-grained sand-stone, which cuts freely in different directions, is used for architecture, and called free-stone. The colour of siliceous sand-stone is generally either red or light-grey, and is sometimes variegated.

MICACEOUS SAND-STONE is principally composed of siliceous sand-stone, containing mica arranged in layers, which gives to the stone a slaty structure. In the West Riding of Yorkshire, this variety of sand-stone is used for the roofs of houses.

SAND-STONE with an argillaceous base, differs from siliceous sand-stone, by containing a larger portion of cement, and is hence softer and less durable. This variety of sand-stone, and the micaceous sand-stones, alternate with coal-strata in all the coal districts of England and Wales.

CALCAREOUS SAND-STONE. — Some varieties of sand-stone have a calcareous cement, and effervesce with acids. Some rocks are composed of particles of shells or coral united by a cement; — such is the sand-stone in which human skeletons are found at Guadaloupe, and a sand-stone of this kind is found on the north-west coast of Cornwall.

CRYSTALLINE GRANITIC ROCKS,

COMPOSED OF GRAINS OF TWO OR MORE SPECIES OF MINERALS, CLOSELY UNITED, WITHOUT ANY VISIBLE CEMENT.

GRANITE is composed of grains or concretions of felspar, vitreous-quartz, and mica. Felspar is commonly the prevailing ingredient, and generally gives to the mass a red, grey, or white colour; when black-mica is abundant, the colour is dark-grey. The concretions which compose granite vary in size, being sometimes as large as a nut, or larger, and sometimes as small as minute grains of sand, and can scarcely be discerned without a lens. The finest-grained granites nearly resemble sand-stone. The quartz, felspar, and mica, often penetrate each other; hence it appears that they were all consolidated or crystallized at the same time.

Granite forms enormous beds, or immense mountains, which are traversed by seams or rents in different directions; it is sometimes rudely columnar. Veins of large-grained granite, often traverse rocks of smaller-grained granite, and veins of small-grained granite, occur in many schistose rocks. Beside felspar, quartz, and mica, which are considered as essential, granite often contains other ingredients, which may be regarded as accessary. Of these, the principal is hornblende. When the hornblende is abundant, the rock is denominated sienite. Schorl and garnets are not uncommon in granite; andalusite and zircon are rare.

PORPHYRITIC GRANITE is a small-grained granite, containing large crystals of felspar imbedded. The granite near Shap in Westmoreland is of this kind.

GRAPHIC GRANITE is composed of masses of crystalline felspar, inclosing dark-grey quartz, arranged in distinct lamellæ, which are so bent, as frequently to resemble Hebrew letters. The felspar is often white. Red graphic granite occurs near Portsoy.

PROTOGINE. — Granite, in which talc, chlorite, or steatite, supply the place of mica, has received the name of *protogine*. This kind of granite, according to Saussure, forms the summit of Mont Blanc.

ORBICULAR GRANITE. — In this rare variety, the ingredients of different colours are arranged in concentric zones. Though called granite, this rock is properly a green-stone, consisting of white felspar, with spheroidal zones of black hornblende or augite?

GNEISS. — When the quantity of mica in granite is abundant, and arranged in parallel layers, it forms a slaty granite, denominated gneiss by the German geologists. Gneiss has a granular internal structure, and a slaty structure in the mass. When broken in the direction of the slaty structure, the mica appears to be the prevailing ingredient; but the cross fracture shows that it is much less abundant than the felspar and quartz. The mica in gneiss is often much intermixed with hornblende. When the quantity of felspar decreases, and mica becomes the predominating ingredient, gneiss passes into mica-slate. See MICA-SLATE, p. 477.

SIENITE is so called from Sienna, in Upper Egypt, where this rock was formerly obtained for architecture. It is composed of quartz, felspar, and hornblende, and sometimes contains mica. Granite, by the addition of hornblende in a considerable proportion, becomes sienite; in like manner, when the mica in sienite increases, and the hornblende diminishes, it passes into granite. The sienite and granite may be seen passing into each other in various parts of the Malvern Hills.

The felspar in sienite is almost always red, but part of it is sometimes coloured green by the hornblende. Sienite has sometimes a coarsely slaty structure, and is sometimes porphyritic, containing large crystals of felspar, imbedded in a small-grained sienite.

ZIRCON SIENITE. — This sienite is so named from containing crystals of zircon; it is composed of felspar, which is sometimes opalescent, and of crystalline hornblende.

GREEN-STONE, Fr. *Diabase.* — The German geologists give the name of green-stone and trap (*Grunstein*) to a rock composed of the same ingredients as sienite, when the hornblende becomes more abundant, and the felspar is white. The term green-stone is vaguely applied to almost all basaltic rocks that have a granular structure. It is now discovered that augite (*Pyroxene*) is frequently the predominating ingredient in many rocks of green-stone. When the constituent parts of green-stone are distinct, the felspar being white, and the hornblende or augite black, this rock has a near resemblance to small-grained granite, in which the mica is black. The constituent parts of green-stone are often so intimately blended, as to present an homogeneous dark colour, either greyish or brownish-black, and it passes from a granular, to nearly a compact slate; it then forms basalt. Green-stone has sometimes a coarsely schistose structure, and is called greenstone-slate, and passes into hornblende-slate.

PORPHYRITIC GREEN-STONE.—In this rock large crystals of felspar are imbedded in finer-grained green-stone.

SIENITIC GREEN-STONE.—In this variety the felspar is sometimes red, and it contains quartz.

The following intermixtures of two crystalline simple minerals, not unfrequently form entire rocks or beds of considerable magnitude in alpine districts:

QUARTZ and FELSPAR.

QUARTZ and MICA, disseminated, *Hyalomcite*, Fr.

QUARTZ and SCHORL, *Cockle* of the Cornish Miners.

QUARTZ and HORNBLENDE.

GRANULAR LIME-STONE and HORNBLENDE.

GRANULAR LIME-STONE and MICA.

GRANULAR LIME-STONE, with spots of Talc or Serpentine.

FELSPAR and AUGITE.

FELSPAR and DIALLAGE, *Euphotide*.

SAUSSURITE and GREEN DIALLAGE.

FELSPAR and CHLORITE.

HORNBLENDE and MICA.

Other crystalline aggregates of two or more simple minerals sometimes occur, forming masses or rocks. The enumeration of them would be attended with little advantage. It is always better to notice such rocks by a short description of the constituent ingredients, and the manner in which they are aggregated, than to invent new names to designate them, as such names can convey no accurate information; and geology and mineralogy are already sufficiently burdened with useless terms.

PORPHYRITIC ROCKS.

PORPHYRY, a name derived from the Greek signifying red, is now generally applied to all rocks which are composed of a nearly compact paste, and contain imbedded crystals, which are most frequently of felspar. The base or paste of the greater number of porphyries is either compact felspar, or a rock nearly allied to compact felspar, called Petro-silex, or Horn-stone. See HORN-STONE. The only true distinction that can be made between hornstone-porphyry and felspar-porphyry, is the infusibility of the former, a property probably derived from its containing a larger portion of silex.

FELSPAR PORPHYRY. — The colour is generally inclining to red or light-grey. The crystals of felspar which are imbedded are white or reddish, or greyish-white; sometimes the paste has a granular structure. Well-characterised specimens of red and grey porphyry occur in beds at Inverary, and the northern parts of Argyleshire. Rounded masses or boulders of very fine dark-red and grey porphyry abound in the cliffs of conglomerate sand-stone near Stonehaven. No rocks precisely similar to these boulders are discovered in any part of Scotland.

HORN-STONE PORPHYRY. See HORN-STONE.

CLAY-STONE PORPHYRY. — The paste has frequently a reddish-grey colour, and the texture is less fine than that of felspar or horn-stone porphyry.

CLINK-STONE PORPHYRY has generally a dark greenish-grey colour, and the crystals of felspar are transparent and splendent. See Glassy Felspar and Clink-stone.

OBSIDIAN-PORPHYRY contains crystals of white felspar in a base of obsidian. See Obsidian, p. 284.

PITCH-STONE PORPHYRY contains crystals of glassy felspar, or of white, nearly opaque felspar, in a base of pitch-stone. See Pitch-stone, p. 289.

GREEN-PORPHYRY contains crystals of greenish-white felspar, imbedded in dark-green compact felspar, or petro-silex.

AMYGDALOID.

This term is applied to those rocks in which other minerals are imbedded in the form of compressed nodules, supposed to resemble the shape of almonds; the term being derived from the Latin *amygdala*, an almond. Amygdaloids have generally a base of wacke or basalt, (see Wacke and Basalt.) and sometimes of compact felspar. When the base is compact felspar, the term variolite is used, to designate the rock. The nodules in amygdaloid are frequently agate, chalcedony, or carnelian, sometimes intermixed with quartz or calcareous spar. When the cavities of wacke are filled with white calcareous spar, it has been called toad-stone. This variety is common in Derbyshire.

Basaltic Amygdaloid, with nodules of agate or chalcedony, occurs in the vicinity of Perth, and in various parts of Scotland.

Basaltic Amygdaloid, with nodules of calcareous spar, occurs in Derbyshire and Gloucestershire.

BRECCIATED-ROCKS,

PRESENTING THE APPEARANCE OF ANGULAR FRAGMENTS UNITED.

These rocks may be classed in two divisions: 1st, those consisting of irregular masses of two or more minerals, which are so intimately blended, as to leave no doubt that they were consolidated at the same time; 2d, those consisting of fragments of pre-existing rocks, united by the intervention of a cement. The latter are called breccias.

The term breccia has also been sometimes applied to rocks in the first division, and it must be confessed that it is often extremely difficult, if not impossible, to ascertain in which of these divisions certain rocks should be arranged.

VERDE-ANTIQUE. — Green serpentine, intermixed with masses of white granular lime-stone, and veined or spotted with lime-stone. See SERPENTINE.

BRECCIATED-LIME-STONE consists of angular masses of different coloured lime-stone, united by a calcareous cement.

In many lime-stone breccias, where we may observe masses of different coloured lime-stone united by veins of calcareous spar, the edges and angles of the fragments are so sharp, that they cannot have been subjected to attrition. Could we suppose a rock of lime-stone to be split into fragments without being removed, and the fissures to be instantly filled by a calcareous cement, this might be sufficient to explain the formation of lime-stone breccias, where the fragments are of one kind; but where the contiguous masses present great diversity of colour and texture, we are led to infer, that the appearance of fragments is deceptive, and that the masses and the cement which unites them are cotemporaneous.

Brecciated rocks may have a siliceous, calcareous, or ferruginous cement. They may consist of fragments of different rocks, united by a cement, or of fragments of the same rocks, united by a cement.

It is unnecessary to give a description of the various breccias, as fragments of every kind of rock may occur in brecciated forms. In the geological description of breccias, it is necessary to notice particularly the minerals or rocks which compose the fragments, and the nature of the cement by which they are united.

PUDDING-STONE consists of rounded nodules or pebbles imbedded in a paste. It differs from cemented breccias, the imbedded masses of which are angular. It differs from porphyry which contains imbedded crystals. Pudding-stone more nearly agrees with amygdaloid, but the base of amygdaloid is basalt or wacke; the base of pudding-stone is generally siliceous. In the finest pudding-stone the base is siliceous and compact, and appears to be a variety of flint; the nodules are also siliceous, and differ little from the paste, except in the colour. Sometimes the paste is even harder than the nodules. In this kind of pudding-stone, the paste and the nodules were probably consolidated at the same time. The coarser kinds of pudding-stone consist of rounded pebbles, which have been enveloped in a mass of sand, clay, or ferruginous earth, which has subsequently become indurated.

VOLCANIC ROCKS.*

Lava is formed by subterranean fire in the interior of the earth, and thrown, in a melted state, out of extensive fissures made in the crust of the globe by heat, or is poured out of the craters of volcanoes. These currents of melted earthy matter are either spread over the bottom of the sea, or on the surface of islands and continents; when cool, they form rocks and stony beds of considerable extent and thickness. The upper surface of these beds is generally more or less vesicular and scoriaceous, and it is only where they are broken through, that the compact state of the lava can be seen. From this circumstance the volcanic origin of compact lava has frequently been doubted, as it was supposed that all lava must be porous; but it has been well observed, that to judge of the substance of a current of lava from what appears on the surface, would be like judging of a vat of wine, from the froth with which it was covered. From the recent observations of M. Cordier, on lava and other earthy volcanic products, it appears that they are composed of a congeries of minute crystals, or grains of different minerals: and he further found, that all volcanic rocks are composed of similar crystalline grains, interlaced with each other, and these grains or crystals

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* Under the article *Volcano,* which I have written recently for Dr. Rees's Cyclopædia, I endeavoured to collect all the most important information which we possess at present, respecting volcanic phenomena.

are of the same kind as the larger crystals often imbedded in lava. The whitish grains are either felspar, leucite, or olivine; the dark-green are augite or hornblende. The black and opaque grains are iron-sand, consisting of grains of iron and titanium. Grains of micaceous iron are scarce; they yield a red powder when pounded. (See the different minerals here enumerated, Book II. and III.)

The two minerals, felspar and augite, compose the greater part of the mass. According to the prevalence of felspar, the lava possesses different characters. Lava, which contains from forty-five to fifty per cent. of felspar, melts into a black glass; black basalts are of this kind. If the felspar exceed fifty-five per cent. and is under seventy it melts into a bottle-green enamel. Such are the greenish and greyish lavas. When the felspar is in the proportion of ninety per cent. it melts into a white opaque or translucent glass. This forms the petro-siliceous lavas, called sometimes compact felspar or clinkstone. All lava may therefore be divided into two kinds, that which melts into a white glass, and that which melts into a black glass. The former, called by Cordier *leucostine*, comprises those substances, called by Dolomieu, petro-siliceous lava; by Haüy, compact sonorous felspar; by Werner, clink-stone. It also appears to comprise some of the harder varieties of clay-stone. The lava that melts into a dark glass, comprises the dark-coloured lavas and basalts.

This view of the subject tends greatly to simplify our arrangement of volcanic products, as all the earthy masses or rocks formed by volcanoes, however differing in structure, density, or colour, are to be regarded only as different aggregations of the same simple minerals. The observations of M. Cordier are confirmed by the examination, of an extensive and well-arranged collection of volcanic rocks I have recently received from Vesuvius, and compared with specimens from Iceland, and other volcanic countries.

Though different lavas are composed of nearly the same ingredients, they are often so variously modified by the different degrees of heat to which they have been subjected, and the circumstances attending their cooling, that no concise mineralogical description can be given, which will agree with all the varieties of lava.

Light-coloured stony lava sometimes occurs in a nearly vitrified state, resembling the opaque white glass frequently formed in glass furnaces, when the substance has cooled slowly. I have specimens of this kind produced during an eruption of Vesuvius in 1809. From this vitrified state it passes into compact felspar or clay-stone. This kind of lava is common in the Island of Lipari.

Dark-coloured stony lavas pass through all the various shades, from a grey to a black, and from the various states of vesicular and porous to compact; from compact they pass into a semi-vitrified state, and from thence into obsidian or black volcanic glass. On examining these lavas with a powerful lens, it will be seen that they are composed, as Cordier has described, of minute crystals or grains of different minerals; and they frequently contain imbedded crystals or grains of larger size, either of augite, leucite, olivine, or basaltic hornblende. I have specimens from eruptions of Vesuvius in 1813 and 1818, which are as compact as the basalt of the Rowley-Hills in Staffordshire, which they closely resemble.

The currents of very ancient lava are frequently compact. These lavas were probably formed when the present continents were covered by the ocean, and were therefore subjected to a high degree of pressure when in a melted state. Some lavas have been found inclosing marine shells.

VESICULAR LAVA, SCORIÆ, or SLAGG, can only be regarded as different forms of lava, tumefied by heat and suddenly refrigerated. The scoriæ or slagg generally presents a semi-vitrified appearance.

VOLCANIC GLASS appears to be formed by some peculiar circumstance attending the cooling of lava; for it is well known from the experiments of Sir James Hall, that lava and basalt form glass, when melted and suddenly cooled; and that the same glass when re-melted and slowly cooled forms stone.

OBSIDIAN, or DARK VOLCANIC GLASS.—(See OBSIDIAN, Book I.) This appears to pass into pitch-stone. (See PITCH-STONE.) Obsidian yields either a black or white glass before the blow-pipe, according to the prevalence of felspar or augite; it may be traced in some instances to where it passes into compact basalt or lava; in other instances, it may be seen passing into pumice.

PUMICE may be regarded as a very light spongy lava, varying in porosity, in texture, and in colour. Pumice appears to be the product of intense heat, operating either on lava or obsidian, and reducing it to a capillary or fibrous state; the light-coloured pumice is formed of lava or obsidian abounding in felspar. Lava and obsidian swell greatly when they are exposed to the action of intense heat, a quantity of gas appearing to be evolved. The evolution of this gas gives to the soft tenacious paste the light and porous form of pumice. In some of the pumice of Lipari, the pores are too small to be seen without a lens. The pumice is, however, sufficiently light to swim on water.

Pumice occurs in beds and masses; it has an irregular fibrous structure, with elongated cells or pores; the lustre is shining and pearly in the direction of the fibres. The colours are very light grey, passing to smoke-grey; it is harsh to the touch, and fusible. It is frequently lighter than water; like other volcanic and basaltic rocks, it consists of silex, with a portion of alumine, potash, or soda; the light-coloured pumice contains only about 1.50 of iron. Pumice is often thrown up by submarine volcanoes, and floats on the surface of the ocean, and has been seen at a distance of many hundred miles from land. Pumice is used for polishing glass and metals, and for various other purposes.

VOLCANIC SAND.—Loose grains and powder of the same kind as those which compose lava, are discharged in considerable quantities during volcanic eruptions, and sometimes spread over very distant countries. The white grains or powder are generally discharged towards the end of the eruption. These grains and powders, improperly called ashes, are the black and white rapilli of the Italians.

VOLCANIC TUFA appears to be formed of the loose sand or powders, together with smaller fragments of lava, which have become consolidated by water and pressure. In some instances, the tufa may have been formed by the volcanic powders and water intermixed together, and thrown out in the form of mud.

TERRAS and POUZZALANI are soft ferruginous tufas, that possess the property of consolidating, when mixed with a portion of lime and employed as a cement.

METEORIC STONES, or METEOROLITES.

The descent of stones from the atmosphere is a fact of which we have now abundant and satisfactory evidence. Numerous instances of this kind are recorded by ancient historians, but more accurate and circumstantial descriptions of the phenomena attending the descent of these stones, may be found in the scientific journals published in various parts of Europe during the last twenty years. Still more satisfactory evidence is furnished by the external characters and the analyses of these stones, for however distant the parts of the world in which they have fallen, they bear for the most part a striking resemblance to each other, and contain nearly the same constituent parts. In many instances, brilliant meteors have been observed moving with great velocity in an horizontal direction, exploding with a loud report, and discharging stony masses, which fell to the earth in an ignited state. Some meteors have been observed to explode repeatedly, and discharge a great number of stones in various parts; others appear to be extinguished by a single explosion. A rushing or whizzing sound has been generally heard as the meteor passed near the zenith of the observer; and from numerous observations of the same meteors made at the same time in distant parts of the country, it is evident that they pass through very elevated regions of the atmosphere.

In some instances, the appearance of a black or grey cloud has been observed moving through a clear sky, from which stones have been discharged. "On the 16th of June, 1794, a tremendous cloud was seen in Tuscany, near Sienna and Radacofâni, coming from the north, about seven o'clock in the evening, sending forth sparks like rockets — throwing out smoke like a furnace — rendering violent explosions and blasts, more like those of cannon and of numerous rockets, than like thunder — and casting down to the ground hot stones — whilst the lightning that issued from the cloud was remarkably red, and moved with less velocity than usual. The cloud appeared of different shapes to persons in different situations, and remained suspended a long time, but every where was plainly seen to be burning and smoking like a furnace; from various observations it seems to have been at a great height. A gentleman who saw the cloud as he was travelling, said it appeared to be much above the common region of the clouds, and was clearly discerned to be on fire, being black at first, but becoming white through two-thirds of its mass, which was originally black, and yet he observed that it was not affected by the rays of the sun which shone full on its lower parts. He could discern as it were the basin of a fiery furnace in the cloud, having a whirling motion."* Several stones were collected that fell from this cloud, and they are precisely similar to those which have fallen from fire balls, as will be seen by the analysis.

Some philosophers conjecture that these stones have been projected from volcanoes in the moon; others that

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* Remarks concerning Stones said to have fallen from the Clouds. By Edward King, F.R.S. 1796.

they are bodies revolving in space, composed of the earths in a metallic state, and that they take fire and explode when they come within the atmosphere of the earth. The most probable opinion is, I conceive, that which ascribes to these stones an atmospheric origin, the different materials of which they are composed, being supposed to exist in an elementary and gaseous state, and to combine and explode, forming stony masses, and at the same time evolving light and heat. The instantaneous formation of masses of ice in the atmosphere during thunder-storms, may perhaps elucidate the formation of meteoric stones. Were the temperature of the earth permanently below 32° of Fahrenheit, these masses would remain as solid stones on its surface. Meteoric stones have generally the following characters:—Their form is oblong or roundish; they vary in weight from a few ounces to some hundred pounds; externally they are covered with a black incrustation, which is principally composed of the oxide of iron; internally the colour inclines to ash-grey, sometimes intermixed with dark brown, so that its aspect at first sight resembles a coarse sand-stone. The grains are brown and opaque, intermixed with particles of metallic iron and iron pyrites, cemented by a light grey earthy matter, which is sometimes so soft as to admit of the easy separation of the imbedded grains. A fragment, in my possession, from a meteoric stone that fell near Chantonay in the road from Nantes to Rochelle, August 1812, possesses a considerable degree of hardness, and yields with some difficulty to the knife; the metallic iron is disseminated through the mass, and it affects the magnetic needle powerfully.

In the following analysis of various meteoric stones, it will be perceived that there is in some instances an increase of weight.

	Silex.	Mag.	Iron.	Nickel.		Sulphur.	
Yorkshire, 1795. Weight 96 lbs. Sp. gr. 3.5.	50	24	32	1.33		—	Howard.
Tipperary, Ireland, 1810.	46	12	42	1.5		4	Higgins.
Sienna, Tuscany, 1794.	46	22	34	2.		—	Howard.
	44	22	27	0.6	Mang. 2.5		Klaproth.
Plann, Bohemia, Sp. gr. 4.28.	45	17	42	2.7		—	Howard.
Angle, Normandy, 1803.	30	32	25	13		1	Vauquelin.
	46	10	45	2		5	Thenard.
St. Etienne, 1806.* Sp. gr. 1.94.	20	9	40	15	Mang. 2.	4	Thenard.
Langles, 1815.	33	32	31	—		—	Vauquelin.
Connecticut, 1807. Sp. gr. 3.6.	41	16	30	Mang. 1.34		2.30	Warden.
		With Aulmine 1. Lime 3.					

The meteoric iron, which has been analysed from different parts of the world, contains from 84 to 96 parts iron, and from 4 to 16 parts nickel.

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* The low specific gravity of this stone must have been owing to its porosity, as it contains 57 parts of metallic matter.

AN

INTRODUCTION

TO

MINERALOGY.

BOOK III.

NATURAL HISTORY AND CHARACTERS OF METALLIC MINERALS.

Essential Characters.

a. SPECIFIC GRAVITY exceeding 5, or *

b. Possess a metallic lustre when scraped, or

c. Sp. gr. from 2½ to 5, destitute of metallic lustre, but are,

1. Reduceable to a metallic state by the blow-pipe; or
2. Rendered magnetic by the blow-pipe; or
3. Volatilized wholly, or in part, by the blow-pipe, yielding a vapour; or †
4. Communicate a colour to borax by the blow-pipe.

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* All minerals whatever that possess either of the characters *a* or *b* are metallic.

† The sp. gr. being above 2½ distinguishes all volatile metallic minerals from the class of combustible minerals.

OBSERVATIONS ON METALLIC MINERALS.

This class comprises all Minerals that are composed of the Metals, either native or alloyed with other Metals — or combined with Sulphur, with Oxygen, or with Acids. The Metals have been already enumerated in Book I. *Chap.* 9. *It is the province of the Chemist to describe their properties when purified, and their application, to the useful arts.*

Metallic Minerals admit of a well-marked division into Genera and Species. Each Metal constitutes a genus, and its combination with other substances forms the species. In some instances, however, where two metals are combined in nearly equal proportions, it is difficult to determine in which genus an ore should be arranged.

In Metallic Minerals, the chemical characters are far the most definite and important, and the crystalline structure holds only a subordinate place, for the primitive form of the crystals of the native Metals cannot be accurately ascertained; and it appears that the same form is common to several. The Chemical Characters are, however, so clearly defined, as to leave nothing to desire with respect to Native Metals, and all the Metallic Minerals that have been long known. But many of the newly-discovered Metals never occur native, and are scarcely reducible to a permanent metallic state from their ores. They also possess properties *which were formerly supposed to belong, exclusively, to the other classes of Minerals; hence it becomes difficult, if not impossible, to give a simple and comprehensive definition of Metallic Minerals.* * *The substances commonly called Metallic, possess, however, so many important properties, as applied to the service of man, that they will continue, by common consent, to be regarded as a distinct class of Minerals, and we must arrange them as such in our systems, so long as we preserve any respect for utility.*

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* The few metals known to ancient nations were well distinguished from other minerals by their peculiar colour and lustre, their great specific gravity, their malleability and fusibility in the furnace. Many of the recently discovered metals approach to the nature of inflammable or of earthy minerals. Tellurium, zinc, and arsenic, inflame at a comparatively low temperature, and the latter metal, so far from being malleable, is instantly reduced to powder by the stroke of the hammer.

The discovery of the metallic nature of the bases of the earths, proves that there are no absolute limits fixed by nature between earthy and metallic minerals, as the definitions of them, generally given, might lead us to conclude. The earths possess the characters of metals when deprived of oxygen, and many of the metals possess the character of earths when saturated with that element. In an extract from *Recherches sur l'identite des Forces Chemiques et Electriques*, by Professor Ærsted, of Copenhagen, given in Dr. Thompson's Annals, May, 1819, there are some valuable observations on this subject.—" What (says he) constitutes a substance a metal? it is obviously its resemblance to other metallic bodies; it was by this successive comparison of bodies as they were discovered, with those already known,

GENUS I. — GOLD.

SP. 1. *Native Gold.* *Gold Dust.*	SP. 2. *Argentiferous Gold,* *or Electrum.*

GOLD was probably the first metal that attracted the notice of mankind, or that was applied to purposes of use or ornament. As it is not rusted or decomposed by air, moisture, or acids *, it preserves its metallic lustre and properties, and is generally found in a metallic state, nearly pure. The great ductility of gold, and its easy fusibility, were properties that enabled the first rude artificers to mould it with facility into various forms, and contributed, no doubt, to stamp a high value on this metal in the earliest ages of civilized society; a value which it has retained from its imperishable nature and comparative rarity. It is probable, that gold and silver, and afterwards copper, were for

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that the class of metals was formed and extended. Unless this had been the case, the characters ascribed to them could not have experienced so many variations. Definitions are merely modes of making ourselves understood, they do not constitute limits really fixed by nature. As science advances, we must overleap these artificial bounds, placed in our way by our predecessors. We must continue our comparisons. The limit of yesterday ought not to continue the limit of to-day, if the progress of science require a new one."

[*] Except chlorine and nitro-muriatic acid, with which, however, it is never found combined in nature.

a long time the only metals used by mankind, as they are the only metals that occur in any considerable quantities in a native state, on or near the surface of the earth; hence, doubtless, originated the tradition of the golden, the silver, and the brazen ages.

Though gold is less abundant than many of the metals, it is distributed over almost every part of the known world, either in veins or disseminated through the sands of rivers or alluvial soil, in loose grains and detached masses. The gold collected by washing the sands of rivers, is called gold-dust. The greatest part of the gold of commerce in Europe, is obtained in this form from Africa and the Brazils. Gold is also found in the sands of rivers in Asia and the Asiatic Islands, and in some parts of Europe. Gold is often combined or intermixed in small proportions with other metals, which are sometimes worked exclusively as gold-ores. It is stated by the French chemists, that gold has been discovered in the ashes of sage and other vegetables.

Sp. 1. NATIVE GOLD is sometimes nearly pure, possessing the softness and ductility, with the gold-yellow colour and lustre, and all the properties of metallic gold. The sp. gr. is 16 to 81 (Lowry); it is fusible into a globule, which remains unaltered by the flame of the blow-pipe. When native gold contains a larger portion of alloy its sp. gr. is diminished, sometimes not exceeding 12. The colour varies with the quantity and nature of the alloy, passing into brass-yellow, and thence into yellowish-grey, inclining to steel-grey.

Native gold occurs in grains and in small pieces of various shapes, and sometimes in masses of several pounds weight; it also is found regularly crystallized, and in thin leaves, or in filaments, or in branches.

The crystals of gold are cubes or octahedrons, but it is uncertain which is the primitive form. The crystals are often variously modified by truncation or bevels, and are sometimes garnet-shaped. Grains and masses of gold are found in sand and alluvial soil; the other forms occur in veins or disseminated through masses of rock.

Distinctive Characters. — Native gold may be distinguished from native copper by its greater specific gravity and insolubility in nitric acid. It is distinguished from copper pyrites or iron pyrites, by its specific gravity and malleability.

Native gold is soluble in nitro-muriatic acid, and is precipitated in a metallic state by sulphate of iron; the latter circumstance distinguishes grey native gold from platina. The solution of gold tinges the skin purple. Writing-paper immersed in it and exposed when wet to a stream of hydrogen gas, becomes purple and spotted with metallic gold.

Native gold is often too minutely disseminated through other minerals to be discerned by the eye. It may be extracted by roasting the mineral, and triturating it with mercury, which dissolves the gold. The mercury may be sublimed by heat, but the gold will remain. If the residue be small, it may be dissolved in nitro-muriatic acid. The solution will be yellow, and communicate a purple colour to the skin. A little of the amalgam of mercury and gold may be rubbed on the surface of silver, and exposed to the flame of a candle; urged by the blow-pipe, the mercury will be driven off, and a thin yellow coat will remain on the silver, which when burnished will have the lustre and colour of gold.

The native gold in veins is generally accompanied by quartz; sometimes the matrix is felspar, carbonate of lime, or sulphate of barytes. The ores most frequently associated with gold in veins are, iron, copper, silver, lead, and antimony, and they are generally sulphurets of these metals. Gold occurs as an alloy of silver; almost all the silver of America, according to Humboldt, being more or less alloyed with gold.

The rocks in which gold occurs in veins, are those which are described by geologists as primary or transition rocks, more particularly granite and porphyry. The rock in which gold is most frequently disseminated is a grey porphyry. Native gold has also been found in the volcanic rocks of the island of Ischia.

Gold Dust, or Pulverulent Gold. — The finest or most pulverulent gold-dust has a reddish-brown colour and but little metallic lustre.

Grains of gold of considerable size, and sometimes masses weighing several pounds or ounces, are likewise found in sand and alluvial soil with gold-dust. Gold is occasionally found in the sands of the rivers in Cornwall, derived no doubt from the disintegration of ancient rocks, which contained auriferous veins. (See Tin.)

The largest specimen I have seen in that county is the size of a bean, and imbedded in quartz. I am informed, that a mass of considerable size was, in one instance, found in a cavity on the side of a vein. Gold is found in the sands of some of the rivers in Scotland. In the county of Wicklow in Ireland, a considerable quantity of gold was found in the year 1796; one mass weighed 22 ounces. Though gold was procured, by the Carthaginians and Romans, from Spain, to the amount of 240,000 ounces annually, no gold has been obtained from thence since the discovery of America. France, and almost every country in Europe, contains a small portion of gold, but Hungary is the only kingdom in this quarter of the globe, where any considerable quantity of that metal is at present obtained: according to Brongniart, the annual produce is about 1700lbs. troy. The gold-mines of Nagyag and Offenbaugh, in Transylvania, contain an alloy of gold and tellurium. See TELLURIUM. For an interesting account of these mines, see Dr. Clarke's Travels, vol. iv.

The quantity of gold obtained from Siberia has been estimated at 4500lbs. troy.

The quantity obtained from the more southern parts of Asia, and from the islands in the Indian Ocean, is considerable, but the amount is not known. According to Marsden, 15,400 ounces are collected annually from Sumatra.

Africa supplies a large quantity of gold in the form of gold-dust or grains. It is collected from the sands of rivers in various parts of that extensive continent; but principally from the middle and southern regions.

Gold has been found in North Carolina in alluvial soil; in the year 1810; 1541 ounces were obtained, in one mass, weighing 28lbs: but the Spanish and Portuguese American provinces yield the greatest quantities of the gold and silver imported into Europe; the annual produce of gold being, according to Humboldt, 45,000lbs. troy, of which about one-third is furnished by the auriferous sands of the Brazils. Gold is said to be found at the feet of the Andes, throughout their whole extent.

Sp. 2. ARGENTIFEROUS NATIVE GOLD, *Electrum.* — This combination of gold and silver is found at Schlangenberg in Siberia, and received from Klaproth the name of *electrum.* It has a pale brass-yellow colour, passing into silver-white: it occurs along with heavy spar and horn-stone, imperfectly crystallized and in leaves. Its constituent parts are — Gold 64, Silver 30. It is not soluble in nitrous or nitro-muriatic acid.

Genus II. — PLATINA.

Sp. 1. *Native Platina.*
2. *Palladium.*
Sp. 3. *Irridium.*

This metal is found in grains in alluvial soil in some of the Spanish Provinces in South America, and with alluvial gold in the Brazils; it has also been found in masses, as large as a pigeon's egg. It is accompanied with the metals palladium, irridium, osmium, and rhodium.

Platina has also been discovered in the grey silver ore of Guadalcanal in Spain.

Sp. 1. NATIVE PLATINA.—The colour is between steel-grey and silver-white; the lustre metallic, varying in intensity from shining to glimmering. The specific gravity of the grains is from 15.60 to 17.50; that of pure platina 21.41. Lowry. It is the heaviest of all metals. The hardness is nearly the same as that of iron; it is malleable and ductile, and may be rolled into leaves, or drawn into wire, not more than the 18,000th part of an inch in diameter. It is infusible by the common blow-pipe, and does not amalgamate with mercury. It is soluble in nitro-muriatic acid.

The Brazilian platina occurs in irregular grains, which are not tarnished, but have little lustre; they contain a small portion of gold and palladium.

The Peruvian platina occurs in grains which are flattened and partially indented and tarnished. The platina in these grains is alloyed with the four metals before-named, and also with a minute portion of iron, copper, and lead.

Sp. 2. PALLADIUM occurs in small grains with platina, and was first discovered and examined by Dr. Woollaston. The grains have the same colour and external appearance as those of platina, except that each grain appears composed of diverging fibres. The specific gravity is about 12.14. It is infusible, but melts with the addition of sulphur. The sulphur may be dissipated by continuing the heat, and a globule of malleable palladium remains. Palladium forms a deep red solution in nitric acid.

Sp. 3. IRRIDIUM occurs in small flattened grains with platina; the colour is a pale steel-grey, the lustre shining and metallic, the structure laminar; it is harder than platina, and brittle; the specific gravity, when pure, is 19.63. Lowry. It acquires a dull black colour by fusion with nitre, but regains its colour and lustre when heated on charcoal. This ore is an alloy of irridium and osmium; it was first examined by Dr. Woollaston.

The metal rhodium has not yet been found forming a distinct species of ore; it occurs only in a small proportion, alloyed with platina. Its specific gravity is 10.64. Lowry.

Genus III. — SILVER.

Sp. 1. *Native Silver.*
  2. *Antimonial Silver.*
  3. *Sulphuretted Silver.*
    Brittle Sulphuretted Silver.
    Black Sulphuretted Silver.
Sp. 4. *Red, or Ruby Silver.*
  5. *White Silver Ore.*
  6. *Bismuthic Silver.*
  7. *Carbonate of Silver.*
  8. *Horn Silver.*

The ores of silver are more numerous than those of gold; they occur principally in veins in alpine districts, and sometimes at great elevations. Silver is also found combined with the ores of other metals. There are few ores of lead that do not contain silver, the quantity is often sufficient to repay the expense of extracting it.

Silver occurs either native or alloyed with antimony, or arsenic, or combined with sulphur.

Sulphuret of silver generally contains some other metallic sulphuret, and sometimes also a small portion of oxygen. Silver is also found combined with carbonic and with muriatic acid. Almost all the ores of silver yield a globule of metallic silver, when heated on charcoal with the blow-pipe. They dissolve in nitric acid, and the silver is precipitated by muriatic acid, forming a white insoluble matter, that is reducible to a globule of metallic silver, and which is not altered by a continuance of the heat on charcoal. The solution of silver in nitric acid, tinges animal substances black, and deposits a coat of silver on copper when immersed in it. These properties characterise the ores of silver when they contain any notable portion of that metal. All the ores from which silver are extracted, are not, properly speaking, ores of silver. Some of the lead ores in Great Britain contain a larger portion of silver in every ton, than some of the poor silver ores in America; but the latter can be got in unlimited quantities.

SP. 1. NATIVE SILVER. — The colour is silver-white, generally inclining to yellow; the lustre is shining and metallic, but sometimes externally tarnished. Native silver occurs crystallized in cubes, octahedrons, and four-sided or six-sided prisms; also in tables and six-sided pyramids. It is frequently found in minute filaments or reticulated, also dendritical and in leaves: it occurs also in amorphous masses, sometimes of several hundred pounds weight. Native silver is soft, flexible, malleable, and ductile, possessing all the properties of metallic silver. The specific gravity varies according to its purity, from 10 to 10.40. Some varieties have not more than one per cent. of alloy, which is antimony: it more frequently contains a larger portion of alloy, either of gold, copper, arsenic, or iron. Native silver is found in small quantities in several of the mines in Devonshire and Cornwall. South of Callington, there is a hill in the river Tamar composed of light-coloured clay-slate; it is intersected by a vein which contains a considerable quantity of capillary native silver, ruby silver, and sulphuret of silver ore; these ores are also disseminated through part of the rock itself. Native silver is found in considerable masses in some of the mining districts that contain silver ores; in others it occurs rarely, and in small quantities. Koningsberg, in Norway, has furnished the largest masses of native silver, some of which are stated to have weighed more than 200lbs. In the magnificent collection of Mr. Heuland, King-street, St. James's-square, there is a most beautiful specimen of native silver, from the Juliana Haab mine at Koningsberg; it is composed of splendent cubes and octahedrons, most elegantly arranged in diverging branches; it weighs upwards of twelve ounces.

Sp. 2. ANTIMONIAL SILVER, *Argent Antimonial.* — This ore is a metallic alloy of native silver and antimony; it is rather a scarce ore of silver; it occurs in veins of granite and grey-wacke at Altwolfach in Swabia, also in the Hartz, and at Guadalcanal in Spain; it is accompanied with the variety called ferro arsenical silver ore, and with other ores of silver. The colour is between silver-white and tin-white; the lustre shining and metallic, but sometimes tarnished red or yellow externally. It is found crystallized in four-sided or six-sided prisms; also amorphous and in roundish pieces or grains. The surface of the prisms is longitudinally streaked, of the masses uneven or rough. The structure is laminar; it yields to the knife, and is sectile in a slight degree, but is easily frangible. The specific gravity varies from 9.40 to 10.00. According to Klaproth, the ore from Altwolfach contains — Silver 84, Antimony 14; that from Andreasberg — Silver 75½, Antimony 24½. Before the blow-pipe the antimony is volatilized, and the metallic silver remains. It is distinguished from native silver by its want of malleability and laminar structure. It is much softer than arsenical pyrites, or white cobalt ore, and may be further distinguished by its being in a slight degree sectile.

Ferro Arsenical Silver Ore, *Argent Arsenifere* and *Ferrifere.* — This variety is of the same colour as antimonial silver, but has generally a black tarnish, but the lustre is shining and metallic in the streak; it is harder than antimonial silver, and the structure is less distinctly laminar. This alloy occurs crystallized in rectangular prisms, also in roundish-shaped masses, and amorphous. Before the blow-pipe, the arsenic is driven off, and a globule of impure silver remains. It contains — Arsenic 35, Iron 44.25, Silver 12.75, Antimony 4. Klaproth.

Sp. 3. SULPHURETTED SILVER, *Argent Sul-*

furé. — This species is a combination of metallic silver and sulphur, and is one of the most common ores of silver. The colour is dark lead-grey, often with an irridescent tarnish externally, but when cut, it appears shining and metallic. It is found crystallized, and in amorphous masses, and also occurs capillary and dendritical, and in leaves, &c. The crystals are generally cubes, octahedrons, and rhomboidal dodecahedrons. The fracture is sometimes flat conchoidal, and sometimes fine-grained uneven. It yields with ease to the knife, and is flexible and malleable. The specific gravity varies from 6.90 to 7.20. Before the blow-pipe the sulphur is driven off, and a globule of silver remains. If sulphuretted silver be slowly heated, the sulphur is sublimed, and the silver appears in twisted filaments, like those of native silver. According to Klaproth, it contains — Silver 85, Sulphur 15. Sulphuretted silver abounds in the mines of Mexico and Peru.

Brittle Sulphuretted Silver contains nearly the same proportions of silver and sulphur as common sulphuretted silver, but it is intermixed with antimony, which renders it easily frangible. The colour is dark lead-grey, passing into iron-black; the lustre is externally metallic and splendent, but is not increased when scraped. It occurs crystallized and amorphous, and in thin plates, and also disseminated. The crystals are regular six-sided prisms, or five-sided or six-sided tables, which intersect each other, forming cells. It yields to the knife; the fracture is small conchoidal or uneven. The specific gravity is 7 20. It melts with greater difficulty than common sulphuretted silver; a globule of imperfectly malleable silver remains. According to Klaproth, it contains—

Silver 66, Sulphur 12, Antimony 10, Iron 5, Copper and Arsenic 0.50, Earthy Matter 1. It occurs in veins, in various silver-mines of Hungary and Saxony.

Black Sulphuretted Silver.—This ore is probably formed from the decomposition of the other ores of silver which it accompanies. It occurs in corroded masses, and in pulverulent incrustations. The colour is dark lead-grey, the lustre dull, but when scraped the streak is metallic; it is more or less sectile. It melts before the blow-pipe into a slagg containing globules of impure silver.

Sp. 4. RED SILVER, or RUBY SILVER, *Argent Antimonié Sulfuré.*—This species is characterised by the red colour which all the varieties yield when powdered, whatever may be their external colour or lustre. The prevailing colours of this species are cochineal-red, or blood-red, generally more or less tinged with lead-grey, into which colour it passes, and has then a semi-metallic or metallic lustre of various degrees of intensity; it is transparent, translucent, or opaque. The lustre of the red and transparent varieties is generally adamantine. Red silver occurs in veins either in masses and grains or botryoidal, dendritical, and in leaves, and also regularly crystallized. According to Haüy, the primitive form is a rhomboid with plane angles of 104° 28′ and 75° 32′. This ore presents fourteen secondary forms. The most common are, an equiangular six-sided prism, or a six-sided prism terminated by three rhomboidal faces (Plate V. fig. 30.); a crystal nearly similar to the metastatic crystal of carbonate of lime (fig. 31.); two incomplete six-sided pyramids joined base to base (fig. 32.) The crystals are small;

their faces are either smooth or streaked. The structure is laminar, but generally concealed. The fracture is uneven or small conchoidal. The specific gravity is about 5.60. It yields easily to the knife, and is very frangible. It decrepitates before the blow-pipe, and melts with a slight effervescence, emitting a white vapour, and leaves behind a globule of metallic silver. It contains—Silver 60, Antimony 10, Sulphur 17, Oxygen 1. Klaproth. An analysis of Vauquelin gives—Silver 56.67, Antimony 16.13, Sulphur 15.07, Oxygen 12.13. According to Proust, the silver in this ore is in a metallic state, united with antimony, or with arsenic, or with both, as a sulphuret. One specimen yielded Sulphuret of Silver 74.85, Sulphuret of Arsenic 25.0, and Oxide of Iron 0.65.

Distinctive Characters.—Red silver is divided into two subspecies by Werner, dark red silver and light red silver. The first yields a cochineal or brick red streak; the second an aurora-red streak. Cinnabar, realgar, red antimony, red copper ore, black sulphuret of copper, and sulphuret of silver, have some resemblance to red silver, but may be distinguished by the following characters. Cinnabar, realgar, and red antimony, are entirely volatilized by the blow-pipe if pure; their specific gravity varies considerably from that of red silver: red or ruby copper effervesces in nitric acid, and the solution communicates a blue colour to ammonia; black sulphuret of copper or vitreous copper yields a blackish streak. Sulphuret of silver has a greater specific gravity, and does not yield a red streak. Red silver ore is found in small quantities in Cornwall; it is a common ore of silver, and is abundant in the mines of Mexico and Peru.

Sp. 5. WHITE SILVER ORE, *Argent blanc*, Brongniart.— This ore ought perhaps to be classed with antimonial lead ore. It is always accompanied by sulphuret of lead, and occurs massive and disseminated in veins that traverse gneiss, in the vicinity of Freyberg. The colour is light lead-grey. The fracture is even, with a glistening metallic lustre; but in those varieties which contain a larger portion of antimony, the structure is fibrous. The streak is shining and metallic.

This ore is easily frangible, though it is slightly sectile and soft. The specific gravity is 5.32. Before the blow-pipe it melts, and is partly evaporated, leaving a globule of impure silver surrounded by a yellow powder. One variety yielded — Lead 41, Silver 9.25, Antimony 21.50, Iron 1.75, Sulphur 22, Alumine 1, Silex 0.75. Klaproth.—In a light-coloured variety he found, Silex 20, and Alumine 7.

Sp. 6. BISMUTHIC SILVER. — This ore has hitherto been found only in one mine, situated in the Shapback in the Black Forest. Its colour is light lead-grey, which becomes darker on exposure to the air; it occurs disseminated and in acicular crystals. The lustre is metallic and glistening; it yields to the knife, and is easily frangible. Before the blow-pipe small metallic globules appear, which on the addition of borax unite, and form a brittle metallic button of a tin-white colour. The constituent parts, according to Klaproth, are—Bismuth 27, Lead 33, Silver 15, Iron 4.30, Copper 0.90, Sulphur 16.30.

Sp. 7. CARBONATE of SILVER, *Argent Carbonaté*, has been found in masses, and disseminated in a vein at Altwolfach in the Black Forest, associated with other ores of silver. Its colour is grey or greyish-black; the fracture is uneven, or earthy. The lustre is glistening and metallic, and is increased in the streak. It is soft and brittle. Its constituent parts are—Silver 72.5, Carbonate of Antimony 15.5, Carbonic Acid 12.

Sp. 8. HORN-SILVER, *Argent Muriaté.* — This is rather a scarce ore of silver; it is distinguished from all other minerals by well-marked characters, and has been compared to horn. Its colours are pearl-grey, or greenish or blueish grey, also blue and green; the lustre is waxy and glistening; it is more or less translucent. By exposure to the air, its colours become darker externally. It possesses the yielding softness of wax, and may generally be indented by the nail. Its specific gravity is about 4.5. It is fusible in the flame of a candle. Before the blow-pipe on charcoal it yields a metallic globule, giving out vapours of muriatic acid. It occurs in small tubercular masses, and incrusting other minerals, also crystallized in cubes, four-sided prisms, and octahedrons. When rubbed on a plate of moistened zinc, it covers it with a film of silver. It contains — Silver 67.75, Iron 6, Muriatic Acid 21, Alumine 1.7. Klaproth. Another specimen from Peru gave—Silver 76, Muriatic Acid 16.4, Oxygen 7.6. Karsten has divided horn-silver into three subspecies, a division which can be attended with no possible advantage in a species where all the varieties are so well characterised by their yielding softness and easy fusibility. It has been discovered in Cornwall, and is abundant in some of the American mines near Potosi.

Earthy horn-silver, or buttermilk silver, appears to be an intermixture of horn-silver and alumine; it was found formerly at Andreasberg in the Hartz, sometimes in a fluid state, but more frequently in soft or nearly fusible incrustations. The colour is a pale greenish or brownish grey; it is opaque, dull, and earthy; the streak is shining and resinous. It contains — Muriate of Silver 32.2, Alumine 69.8. Klaproth.

According to Humboldt, the silver annually obtained from New Spain and South America before the present struggle for independence, was

	lbs. troy.
New Spain - -	1,115,024
Chili - - -	14,154
Peru - - -	292,650
Buenos Ayres -	229,528

Amounting to more than seven million pounds sterling. According to Helms who visited South America, the quantity of silver is so great in many parts of the Cordilleras, that if they were explored and worked, silver would be as plentiful as copper. The mines of Potosi in Peru, are situated in an isolated mountain of soft clay-slate, which is traversed in every direction by silver veins, containing as a matrix ferruginous quartz; it was discovered in 1545. The mountain of Jauricocha, six miles from Pasco, is a mass of silver ore about half a mile in diameter, and fifteen fathoms in depth. The basis is a ferruginous clay, through which the silver is disseminated in the proportion of about nine marks to every cwt. The Mexican mines are more numerous and productive than those of Peru. The vein of Valenciana, in the Intendency of Guanaxuto, is 40 fathoms in width. Silver occurs in France, Spain, Germany, Hungary, Bohemia, and Norway, in the Altaian chain of mountains, and some other parts of Siberia. A considerable quantity of silver is obtained from some of the lead ores in England. See LEAD.

GENUS IV. — MERCURY.

Sp. 1. *Native Mercury.*
2. *Native Amalgam.*
3. *Sulphuret of Mercury, or Cinnabar, or Hepatic Cinnabar.*
Sp. 4. *Muriate of Mercury.*

Fluidity at the common temperature of the atmosphere, together with its splendent metallic lustre, its silver-white colour, and specific gravity of 13.56, distinguish mercury from all metallic minerals. It is volatilized at a red heat; and at a temperature of 40 degrees below the zero of Fahrenheit, it becomes solid and malleable, and has a specific gravity exceeding 15; it also crystallizes in octahedrons. The ores of mercury are not numerous; it is found native and combined with silver, with sulphur, and with muriatic acid. The presence of mercury may be ascertained by mixing the ore with iron-filings, and exposing the mixture to a red heat, under a cool plate of copper; the mercury is driven off, and condenses in globules on the copper.

The ores of mercury are not widely distributed over the globe; they occur principally in strata of sand-stone, and bituminous schist, secondary lime-stone, and ferruginous clay. The ores occur in irregular masses of considerable magnitude more frequently than in veins, and are sometimes accompanied with ores of lead, zinc, and iron. Mines of mercury are wrought at Almaden in Spain, at Idria in Carnolia, in the Lower Palatinate, and in the Duchy of Deuxponts. At Guancavelica, in Peru, cinnabar occurs in an enormous mass, fifty yards in width, which has been worked to the depth of 500 yards; it traverses sand-stone and lime-stone near the summit of one of the Cordilleras 12,000 feet above the level of the sea. The ore is now poor and nearly exhausted. There are other mines of mercury in New Spain and Grenada. According to Humboldt, the quantity of mercury annually employed in America in the extraction of the precious metals by amalgamation, is about 25,000 quintals; the greatest part was supplied from the mines of Almaden in Spain.

Sp. 1. NATIVE MERCURY.— The characters are described above, as it is pure metallic mercury. It occurs in minute globules disseminated in other ores of mercury, and in the minerals that accompany them, as sand-stone, bituminous-shale, sulphate of barytes, and calcareous-spar.

Sp. 2. NATIVE AMALGAM, or ARGENTIFEROUS MERCURY. — The colour is silver-white or greyish-white; the lustre metallic, often tarnished externally; it is more or less solid and brittle, according to the proportion of silver. It occurs in plates, and in small globular or amorphous masses, and disseminated, also crystallized in octahedrons, and in dodecahedrons truncated on the edges, (*Emarginé*, Plate V. fig. 28.) The crystallized amalgam contains — Mercury 72, Silver 27. Its specific gravity is 14.11. It is soft, and creaks when cut. It whitens the surface of copper when rubbed warm upon it. Before the blow-pipe, the mercury is driven off, and the silver remains. It is found principally at Rosenau in Hungary, and in the Palatinate.

SP. 3. SULPHURET OF MERCURY, or CINNABAR.—Its colour is scarlet, cochineal-red, and reddish-grey; the colour of the powder is always red, and often a bright vermilion. It is volatilized with a blue flame and a sulphureous odour; when pure no residue is left. The specific gravity varies from 7.10 to 8.16. It occurs amorphous, lamellar, fibrous, pulverulent, and crystallized. Its constituent parts are — Mercury 84.50, Sulphur 14.75.

Amorphous cinnabar occurs in red masses which have a granular and sometimes a compact texture; it often inclines to brownish-red; it is glimmering or dull, and nearly opaque.

Lamellar cinnabar is straight or curvedly lamellar, and superficially striated. It is translucent, and the lustre is shining, and sometimes semi-metallic.

Fibrous cinnabar is rare; its colour is a bright red; its structure fibrous, and lustre silky.

Pulverulent cinnabar is called flowers of cinnabar, or native vermilion.

Crystallized cinnabar occurs in regular hexahedral prisms, which is the primitive form. This prism is sometimes terminated by six small oblique planes (Plate V. fig. 29.) It occurs also in pyramids with four, six, or eight sides; the lustre is splendent, approaching to semi-metallic; it is translucent.

Cinnabar is sometimes mixed with earth and other impurities, and has received the name of hepatic cinnabar.

Hepatic Cinnabar has a reddish-brown colour, sometimes inclining to lead-grey. It occurs both compact and slaty; the lustre is glistening and semi-metallic; it is easily frangible and sectile. It contains — Cinnabar 95, mixed with Carbon, Silex, and Alumine, and a trace of Copper. Sometimes the quantity of carbon or bituminous matter is considerable. The ore in the mine of Idria is principally this variety, and is called *Branderz.* (Brongniart.)

Sp. 4. MURIATE of MERCURY, or HORN QUICKSILVER. — Its colours are pearl-grey or yellowish-green. It is sectile, but has not, like muriate of silver, the yielding softness of wax. It is commonly translucent. It is volatilized entirely by the blow-pipe, and is soluble in water. It occurs in tubercular crusts, and massive; also in small dodecahedral crystals. It contains — Oxide of Mercury 76, Muriatic Acid 16.4, Sulphuric Acid 7.6. Klaproth. It accompanies other ores of mercury in the Palatinate, &c.

GENUS V. — COPPER.

Sp. 1. *Native Copper.*
2. *Black Sulphuret of Copper.*
   Black Copper.
3. *Yellow Sulphuret, or Copper Pyrites.*
   White or Arsenical Copper.
4. *Purple Copper.*
5. *Grey Sulphuret, or Grey Copper.*
6. *Red, or Ruby Copper.*
   Amorphous red Copper.
   Capillary red Copper.
   Ferruginous red Copper.
7. *Blue Carbonate, or blue Copper.*
Sp. 8. *Green Carbonate, or Malachite.*
   Compact Malachite.
   Fibrous Malachite.
   Earthy, or Chrysocolle
9. *Dioptase.*
10. *Muriate of Copper.*
11. *Phosphate of Copper.*
12. *Sulphate of Copper.*
13. *Arseniate of Copper.*
   Copper Mica.
   Trihedral Arseniate.
   Prismatic Arseniate.
   Hematitic Arseniate.
   Amianthiform Arseniate.
   Martial Arseniate of Copper.

COPPER was known at an early period of civilised society. Before the general introduction of iron, it was fabricated into swords and other cutting instruments, a considerable degree of hardness being communicated to it by a small alloy of tin. Copper is occasionally found nearly pure, in large masses, on the surface of the earth; this was probably the cause of its early discovery, as copper is obtained from most of its ores with considerable difficulty. Copper is found combined with several of the metals, and with sulphur, oxygen, and various acids; hence its ores are numerous. The presence of copper may be known by roasting the ore and dissolving it in nitric acid, the solution will cover the clear surface of iron with a plate of metallic copper, the solution will also communicate a bright blue colour to ammonia. Copper occurs in veins and in beds. It is more abundant in rocks called primary, than in secondary strata. Its properties as a metal are well known, and it would exceed the limits of the present work to describe its numerous and important uses.

All the species of copper hereafter described, and their principal varieties, except Dioptase and Muriate of Copper, are found in England, particularly in Cornwall. That county is one of the principal repositories of copper in Europe, yielding annually about eight thousand tons of metal, the greater part of which is smelted near Swansea, where fuel is plentiful. In the last century, a large quantity of copper of the best quality was obtained from the Ecton mine in Staffordshire, and the Paris mine in Anglesea; both these mines are at present nearly exhausted.

In the reign of Elizabeth, the copper mines near Keswick in Cumberland were extensively worked. In one mine, called the Gold Scoop, the ore, which is yellow copper, was said to contain much gold, and was therefore claimed by the crown as an ore of gold. This occasioned so much interruption to the operations, that when the mine was afterwards restored to the proprietors, it was found full of water, and has not since been worked. The copper ore in the alpine part of Cumberland occurs in beds of soft schist; in the eastern part of the county this ore occurs in veins. Though the metallic veins abounding in both tin and copper have been worked in Cornwall for more than two thousand years, the copper ore was thrown away as useless, until about the beginning of the 17th century: this is the more remarkable, as the same species of ore was worked in Cumberland, as before mentioned, in the reign of Elizabeth.

SP. 1. NATIVE COPPER possesses the lustre and the yellowish-red colour of metallic copper; it is frequently tarnished externally, and is sometimes greenish or black, but when scraped it is splendent and metallic. Native copper occurs crystallized in cubes, octahedrons or cubo-octahedrons, and in short six-sided prisms, terminated by six-sided pyramids, and in rhomboidal dodecahedrons. The crystals are generally aggregated in groups or branches. It occurs likewise in amorphous masses and in plates, also filiform, dendritical, botryoidal, and in tufts like moss. It is perfectly sectile, and is malleable and flexible. It is harder than native silver. The specific gravity varies from 7.70 to 8.50. Before the blow-pipe, it melts into globules of copper, which appear to be pure.

Native copper may be distinguished from copper nickel by its malleability and inferior hardness; from native gold by its inferior specific gravity, and its solubility in nitric acid; from native silver by its colour. Immense masses of native copper are found in North America. Part of a mass, brought by Mr. Hearne from Hudson's Bay, is in the British Museum.

Sp. 2. BLACK SULPHURET of COPPER, VITREOUS COPPER, and COPPER GLANCE, *Cuivre Sulfuré*, Haüy, *Kupferglanz*, Werner. — Its colour is dark lead-grey or iron-grey, sometimes black or tarnished superficially. Its specific gravity varies from 4.80 to 5.40. Some varieties are perfectly sectile, but the parts cut off by the knife, are in separate grains, and not in adhering slices as in the sulphuret of silver. This ore occurs in compact amorphous masses, and sometimes crystallized in regular six-sided prisms, which, according to Haüy, is the primitive form. The prisms are short and frequently truncated on the terminal edges; it also occurs in pyramidal dodecahedrons, the summits are sometimes truncated. Some varieties have a distinct laminar structure. The fracture is imperfectly conchoidal, with a glistening metallic lustre. Before the blow-pipe, it forms a grey metallic globule containing iron, and is frequently magnetic. Its constituent parts are — Copper 78, Sulphur 18.5, Iron 2.25, (Klaproth); or Copper 81, Sulphur 12, Iron 4, (Chenevix). Black sulphuret of copper is softer than the grey sulphuret, the latter is brittle. Black sulphuret of copper occurs at Frankenburg in Hessia, in the form of compressed ears of corn. *Cuivre spiciform*, (Brongniart). — This ore occurs abundantly in many of the mines of Cornwall; it occurs also in mountain lime-stone and sand-stone at Middleton Tyas in Yorkshire. It is found in various parts of Europe and in North America.

Variegated Vitreous Copper, *Cuivre sulfuré hepatique.* — This variety is of the colour of tempered steel, or violet-blue or green; it accompanies the black sulphuret.

Black Copper, *Le Cuivre Noir*, Brongniart, is of a brownish-black colour: it occurs in dull friable masses, or in incrustations on the surface of other ores of copper, and is evidently derived from their decomposition. It melts before the blow-pipe, and a sulphureous vapour is exhaled.

Sp. 3. YELLOW SULPHURET, or COPPER PYRITES, *Cuivre Pyriteux.* — This is one of the most abundant ores of copper; its colour is a brass or gold-yellow, but is often superficially tarnished; the lustre is metallic. It occurs in amorphous masses, also mamillated, stalactitical, cellular, dendritical, and crystallized in tetrahedrons, which are frequently truncated on the angles or edges, also in cubes, octahedrons, and rhomboidal dodecahedrons. The tetrahedron is stated by Haüy to be the primitive form. The structure of the crystallized varieties is laminar; of the mamillated and botryoidal, granular. The specific gravity varies from 4.16 to 4.30. Copper pyrites yields to the knife. The composition of different varieties of this ore varies considerably, some containing a larger portion of iron than others.

The constituent parts, according to Lampadius, are— Copper 41, Iron 17.1, Sulphur 14. A specimen of mamillated copper pyrites yielded—Copper 30, Iron 53, Sulphur 12, Silex 5. Chenevix.

Before the blow-pipe on charcoal, it is reduced with difficulty to a metallic globule.

Distinctive Characters. — Copper pyrites bears a great resemblance to iron pyrites, but it is much softer, yielding to the knife; its colours are generally of a deeper yellow and tarnished or irridescent. The inferior specific gravity, and want of malleability, distinguish copper pyrites from native gold, which it sometimes nearly resembles in colour and lustre.

Copper pyrites is one of the most abundant products of the mines of Cornwall, and is raised, in some instances, from depths exceeding 400 yards; the matrix is quartz. After all the expense of obtaining and dressing the ore, its value varies from about 7*l.* to 9*l.* per ton, and the average per cent. of pure metal obtained from the ore in that county, does not exceed from 8 to 9 per cent. This ore of copper occurs in a pipe vein at Ecton in Staffordshire, which traverses mountain limestone; it was formerly very productive, and worked to the depth of 470 yards, being the deepest mine in England.

WHITE COPPER, OR ARSENICAL COPPER PYRITES, *Cuivre blanche.* — This ore appears to differ from yellow pyrites by containing a portion of arsenic, and forms the passage from yellow to grey copper ore; its colour is yellowish-white, with a glistening metallic lustre. Before the blow-pipe it gives out white arsenical vapours, and forms a greyish-black slagg. The specific gravity is about 4.50. It yields to the knife. One variety of white arsenical copper crystallizes in cubes and octahedrons.

SP. 4. PURPLE-COPPER, *Cuivre pyriteux hepatique,* Haüy, *Buntkupfererz,* Werner. — This ore passes through various changes of colour by exposure to the atmosphere, from a mixture of copper-red and brown, it acquires an irridescent tarnish, passing from red to violet, blue, and green. The lustre is shining and semi-metallic. It occurs massive and crystallized in cubes, the angles of which are frequently truncated, and the surfaces convex.

The specific gravity varies from 4.90 to 5.40. It yields to the knife, giving a reddish streak. It is slightly sectile, but is also easily frangible. It effervesces in nitric acid. Before the blow-pipe, it melts into a globule, which is magnetic. It contains, according to Klaproth, Copper from 58 to 69, Sulphur 19, Iron 18 to 7.5, Oxygen 4 to 5. It occurs, with other ores of copper, near Redruth in Cornwall.

Sp. 5. GREY SULPHURET of COPPER, *Cuivre Gris Arsenié*, Haüy, *Falerz*, Werner.—The colours are steel-grey, lead-grey, or iron-black. It occurs in amorphous masses, also disseminated and crystallized; the crystals are small tetrahedrons, but frequently truncated; their surfaces are shining and metallic. The specific gravity is about 4.50. It yields to the knife. The powder is blackish or reddish-brown. The fracture is uneven or imperfectly conchoidal. Before the blow-pipe it gives out arsenical vapours, and melts into a brittle grey globule. Different specimens of this ore vary considerably in their constituent parts. One variety yielded—Copper 52, Iron 33, Sulphur 14. Chenevix. Some varieties from Germany, according to the same chemist, contained from 5 to 38 parts of antimony, without either lead or silver; whilst one specimen from Andreasberg yielded (Klaproth) Silver 14.77, and another from Cremnitz yielded Silver 2.25, Lead 34. The specimens that yield a reddish-brown streak, are said to be the most abundant in silver. This ore is found in various parts of Europe, and in a few of the mines in Cornwall and Devonshire.

Sp. 6. RED-COPPER, or RUBY-COPPER, *Cuivre Oxydé Rouge*, Brongniart, *Rothkupfererz*, Werner.—The colour of this ore is cochineal-red of various tints, sometimes passing into lead-grey. It occurs amorphous, and crystallized in cubes, or octahedrons variously modified, also in rhomboidal dodecahedrons. The primitive form is the regular octahedron. The crystals are small and generally aggregated, their surfaces are externally splendent. The internal lustre is more or less shining, and often approaching to metallic. The crystals are transparent or translucent; the massive ore is nearly opaque. The structure of the crystals is imperfectly laminar; the cross fracture is granularly uneven, or sometimes imperfectly conchoidal. The specific gravity is 5.69. (Lowry.) It yields to the knife, and gives a brownish streak. Before the blow-pipe on charcoal, it is easily reducible to the metallic state. This ore, from Siberia, contains — Copper 91, Oxygen 9. Klaproth. From Cornwall—Copper 88.5, Oxygen 11.5. Chenevix.

Amorphous Red Copper Ore occurs massive, in plates, and spongiform; its colour is dark cochineal-red; it is nearly opaque.

Capillary Red-Copper consists of delicate filaments, which are generally aggregated; the colour is scarlet or crimson, the lustre shining, the filaments are translucent or transparent.

Ferruginous Red-Copper, *Tile Ore*, is of a reddish-brown or brick-red colour, passing into metallic lead-grey; it is opaque, and the lustre dull or glimmering; it occurs massive, botryoidal, and disseminated. The fracture is commonly earthy, or flatly conchoidal; it yields to the knife, and sometimes to the nail. It blackens, but does not melt before the blow-pipe. It communicates a muddy-green colour to borax.

Red or Ruby-Copper is often accompanied with native copper. In the British Museum, there is an octahedral crystal of red copper, formed on the surface of an ancient copper coin.

Sp. 7. BLUE CARBONATE of COPPER, COPPER AZURE, *Cuivre Carbonaté bleu*, Haüy, *Kupferlazur*, Werner.—The colour is azure-blue, inclining to indigo or blackish-blue; it is more or less translucent; the lustre is shining and between vitreous and resinous. It leaves a blue mark when rubbed upon paper; the powder or streak is a light-blue. Blue carbonate of copper occurs in small crystals, and frequently in small globular or botryoidal masses, which have a radiated internal structure, also stalactitical and incrusting. The crystals are minute, and generally imperfect. This ore is extremely brittle and frangible. The specific gravity varies from 3.20 to 3.50. It dissolves with effervescence in nitric acid. Before the blow-pipe, it gives a metallic globule on the addition of borax, forming at the same time a beautiful green glass. Its constituent parts are — Copper 56, Oxygen 14, Carbonic Acid 24, Water 6. It occurs in veins with other ores of copper, particularly the green carbonate.

Earthy Blue Carbonate of Copper. — The colour is pale-blue; it occurs in friable incrustations, or masses, composed of dull earthy particles.

Sp. 8. GREEN CARBONATE of COPPER, or MALACHITE.—This ore of copper has always a green colour more or less pure. The lustre is generally glistening and silky; it may be scratched with a knife; the powder is green. It effervesces in nitric acids. Before the blow-pipe on charcoal, it yields a globule of metallic copper, but more readily on the addition of borax. It contains — Copper 58, Carbonic Acid 18, Oxygen 12.5, Water 11.5. Klaproth. Copper 56, Carbonic Acid 27, Oxygen 14.2, Silex 1, Lime 1. Green carbonate of copper, or malachite, occurs compact, fibrous, and earthy.

Compact Malachite, *Cuivre vert concretioné*, occurs in mamillated or reniform concretions, also stalactitical, in plates, and amorphous. The structure of the concretions is curvedly lamellar in one direction, and fibrous in the other. The colours are various shades of green, which are often intermixed in the same specimen. Compact malachite is sometimes cut and polished for snuff-boxes or small tables, and is highly prized on account of the beauty of its colours.

Fibrous Malachite. — The fibres are delicate and capillary, and are diverging or stellular. The colour is generally emerald-green, and the lustre is shining and silky. This variety is most frequently found forming an incrustation on the surface of other ores.

Copper-Green, or Earthy Malachite. Chrysocolle, *Cuivre carbonaté terreux*, Haüy. — The colours vary from verdigris and emerald-green, to greenish, reddish, or blackish-brown; the latter is called pitch copper. It occurs massive, stalactitical, botryoidal, and reniform, also incrusting other ores of copper. The fracture is earthy, passing to conchoidal; it has little lustre, and is opaque or translucent at the edges. It is often much intermixed with siliceous earth. Before the blow-pipe, it is infusible without the addition of borax; it then yields a metallic globule. According to Klaproth, it contains — Copper 40, Oxygen 10, Carbonic Acid 7, Water 17, Silex 26.

Sp. 9. EMERALD-COPPER, or DIOPTASE, *Cuivre Dioptase*, Haüy.—Its colour is emerald-green. It occurs in crystals which are elongated dodecahedrons. The structure is lamellar, with a three-fold cleavage, parallel to the faces of an obtuse rhomboid. It is translucent or semi-transparent. The specific gravity is 3.30. It scratches glass. Before the blow-pipe, it tinges the flame green; with borax it yields a metallic globule of copper. It contains — Oxide of Copper 55, Silex 33, Water 12. Dioptase has only been found, hitherto, in Siberia. It resembles the emerald, but is softer, and is distinguished by its crystalline form, and by the negative electricity it acquires by friction.

The remaining species are of little importance to the metallurgist, being never worked exclusively as ores of copper.

Sp. 10. MURIATE of COPPER has hitherto only been found in Peru and Chili, and in some of the lavas from Vesuvius. It occurs crystallized and in grains.

The colours are grass-green or leek-green. The crystals are small octahedrons, often elongated, and variously modified and aggregated; they are transparent or translucent, and have a laminar structure Muriate of copper is reducible to a metallic state by the blow-pipe, and soluble in nitric acid, communicating a blue-green colour to the flame. In the specimens which I have of this mineral from Vesuvius, the colour is pale-green; it forms an incrustation on lava, which might be mistaken for moss; the crystals are wedge-shaped and extremely minute. This ore contains—Oxide of Copper 73, Muriatic Acid 10, Water 17. Klaproth.

SP. 11. PHOSPHATE OF COPPER, *Cuivre Phosphaté.*—Its external surface is blackish-green; internally, the colour is between emerald and verdigris-green; it is more or less translucent; the lustre vitreous or pearly. It occurs in minute crystals, which are either elongated or wedge-shaped octahedrons. The crystals form drossy incrustations; it also occurs in mamillated concretions, with a fibrous structure, and is sometimes compact. It contains — Copper 68.13, Phosphoric Acid 30.95. Before the blow-pipe it melts immediately into a brownish globule, but afterwards spreads on the charcoal and acquires a greyish-red metallic colour. It is found in a mine near Plymouth, on Gunnis Lake, and at Firneberge, near Cologne.

SP. 12. SULPHATE OF COPPER. — This combination of copper is soluble, and described among the salts.

SP. 13. ARSENIATE OF COPPER, *Cuivre Arseniaté*, Haüy. — The combination of copper with arsenic acid presents several varieties, differing greatly in form and colour. The following chemical characters distinguish this species: — When pulverised it immediately communicates a blue colour to ammonia; it decrepitates on charcoal before the blow-pipe, emitting arsenical vapours, and the parts, in contact with the charcoal, are reduced to a metallic state; and it dissolves without effervescence in nitric acid. This distinguishes it from the carbonates.

OCTAHEDRAL ARSENIATE, *Lenticular Copper Ore*, *Linsenerz*, Werner. — The colour varies from light-blue to dark-green; the lustre is vitreous; it is transparent or translucent. It occurs crystallized in obtuse octahedrons nearly lenticular. Its specific gravity is 2 88. It yields to the knife. It contains — Oxide of Copper 49, Arsenic Acid 14, Water 35.

COPPER MICA, or HEXAHEDRAL ARSENIATE, *Cuivre Arseniaté lamelliform.* — The colour is generally a bright emerald-green, sometimes pale blueish-green. The lustre is splendent and pearly. It occurs massive and in thin hexagonal tables, with a distinct lamellar structure, parallel to the hexagonal planes. The massive variety is translucent, the crystallized transparent. Its specific gravity is 2.54. It is softer than calcareous spar. Before the blow-pipe with borax, it yields a globule of copper. The constituent parts are — Oxide of Copper 58, Arsenic Acid 21, Water 21. Chenevix. This ore is peculiar to the mines of Cornwall.

TRIHEDRAL ARSENIATE OF COPPER occurs massive and crystallized, in irregular octahedrons, and in three, four, and six-sided prisms, and in acute rhomboids. The colour is deep blueish-green, passing into black. Before the blow-pipe it flows like water, and on cooling crystallizes in small rhomboidal plates of a brown colour. It contains—Oxide of Copper 54, Arsenic Acid 30, Water 16. Chenevix.

PRISMATIC ARSENIATE, or OLIVEN ORE. — The colour is olive-green, passing into blackish-green. It occurs in small crystals, which form drusy incrustations. The crystals are generally rhomboidal prisms with dihedral terminations. Their surfaces are smooth, shining, and splendent. It also occurs granular and capillary. It yields a straw-coloured streak. Its constituent parts are — Oxide of Copper 60, Arsenic Acid 39.7.

HEMATITIC ARSENIATE is greenish, brownish, or whitish-yellow. It forms incrustations on other arseniates of copper, and also occurs in mamillated concretions. The structure is delicately fibrous, and diverging, with a silky lustre. Its hardness is variable. It contains — Oxide of Copper 50, Arsenic Acid 29, Water 21.

AMIANTHIFORM ARSENIATE. — The colour is blueish and grass-green, also brown, yellow, and white. It occurs in extremely minute flexible fibres, either parallel or diverging, or in very minute laminæ. It contains— Oxide of Copper 50, Arsenic Acid 29, Water 21.

MARTIAL ARSENIATE OF COPPER, *Cuivre Arseniaté Ferrifere.* — This ore is found with arseniate of copper, and other ores of that metal. The colour is sky-blue or greenish-blue. It occurs in minute rhomboidal prisms, terminated by low four-sided pyramids; the acute edges of the prism are frequently truncated; the crystals are aggregated in globular or roundish concretions; the lustre shining and vitreous. It is transparent. The specific gravity is 3.4. It is harder than calcareous spar. The constituent parts are — Oxide of Copper 22.5, Oxide of Iron 27.5, Arsenic Acid 23, Water 12, Silex 6. Chenevix.

GENUS VI. — TIN.

SP. 1. *Oxide of Tin or Tinstone.*
Wood Tin.

SP. 2. *Sulphuret of Tin, or Bell-Metal Ore.*

TIN has not hitherto been discovered in a native state. It is found combined with oxygen, and in one instance with sulphuret of copper. Tin-ore occurs in quartz veins that traverse mountains of granite and schist, and is sometimes disseminated in rocks; it is also found in grains and rounded pebbles, in the sands of rivers and of valleys. The ores of this metal are not widely distributed over the globe. Tin occurs in part of the Saxon Erzebirge, in rocks nearly similar to those of Cornwall; it is found in Gallicia in Spain, and in small quantities in the granite of Puy les Vignes, in Haut Vienne in France. Cornwall is the principal repository of this metal in Europe; the mines of that county were worked by the Phœnicians and Carthaginians, and afterwards by the Romans; the description given of these mines by Diodorus Siculus evidently refers to metallic veins, and not to stream works. Tin is found in the East Indies in Banco and Malacco, and also in Sumatra, Siam, and Pegu ; it has been found in Mexico, and in alluvial deposits in Chili. The ores of tin are distinguished by their great hardness and specific gravity. When roasted and mixed with glass, they form before the blow-pipe a milk-white enamel.

Sp. 1. OXIDE of TIN, or TIN-STONE, *Etain Oxydé*, Haüy. — This ore occurs in masses, which are generally more or less crystalline, also in regular crystals. The colours of massive tin-stone are dark-brown or reddish-brown; the lustre glistening and resinous. The crystals are yellowish-brown, hair-brown or brownish-black, sometimes they are nearly colourless ; the surfaces are generally smooth and splendent, they vary from semi-transparent to opaque. The colour of the powder is light grey. Tin-stone is one of the hardest of metallic ores, giving sparks with steel ; its specific gravity is from 6.30 to 7.00. The structure of the crystals is laminar, with joints parallel to the sides and diagonal, of a rectangular prism. The primitive form is an obtuse octahedron, the planes at the apex form angles of 112° 18′, and at the common base of the two pyramids, angles of 67° 42′, Haüy : the base is square. The common secondary forms are a four-sided rectangular prism, terminated by four-sided pyramids when the lateral edges of the prism are truncated ; it forms the *dioctahedre* (Plate V. fig. 16.); another form, the *opposite*, is represented fig. 17.; and an *hemitrope* crystal, fig. 18. Tin-stone when finely powdered is reduced to the metallic state before the blow-pipe on charcoal. Its constituent parts are--Tin 77.5, Oxygen 21.5, Oxide of Iron 0.25, Silex 75. Klaproth.

Wood-Tin occurs in roundish or reniform concretions, or in wedge-shaped pieces; the structure is divergingly fibrous in one direction, but in the other it is composed of concentric lamellæ. The colours are light yellowish-brown and hair-brown, disposed in concentric zones; the lustre is glimmering and silky. In some instances the fibres diverge from a small dark globule, surrounded by a circle of light yellow, this has been called *bird's-eye tin.* The fibrous structure is, I conceive, owing to an internal arrangement of the particles, produced by an incipient state of decomposition, a process which may often be observed in other species of minerals. Wood-tin is found in the sands of rivers with stream-tin.

Stream-tin, *Etain Oxydé granuliform.*— The grains and fragments of tin-stone found in the sands of rivers, and on some part of the sea-coast in Cornwall, are called stream-tin, because they are obtained by passing a stream of water repeatedly over the sand, which separates the earthy matter from the ore. There can be little doubt, that the grains and fragments of tin-stone which are always rounded by attrition, were detached from veins which once intersected rocks, that have been partly disintegrated and washed down. In some instances, fragments of certain rocks that accompany the stream-tin, indicate the situations from which it has been detached, as similar rocks may be discovered near the sources of the rivulets, in the higher parts of the country. Small pieces of gold are sometimes found with the stream-tin; these were in all probability detached in a similar manner from veins, that have been long since worn down.

Sp. 2. SULPHURET of TIN, *Etain Sulphuré.*—The colour of this ore varies from steel-grey to yellowish-white; the lustre is glistening and metallic; it occurs massive; the fracture is granular and uneven, or flatly conchoidal. Sulphuret of tin yields to the knife, but is not sectile; its specific gravity is 4.30. Before the blow-pipe it emits a sulphureous odour, and fuses into a black slagg. It contains—Tin 34, Copper 36, Sulphur 25, Iron 2, Klaproth; another analysis by the same chemist gave —Tin 26.5, Copper 30, Iron 12, Sulphur 30.5. This rare ore has only been found at St. Agnes in Cornwall, and in small quantities in other mines in that county.

Genus VII. — NICKEL.

Sp. 1. *Copper Nickel.*	Sp. 2. *Nickel Ochre.* *Black Nickel Ore.*

This metal when purified has a brilliant silver-white colour, and is tenacious and ductile, but extremely difficult to melt; it does not oxidate by exposure to the air, and is capable of acquiring magnetism. Nickel cannot be properly said to occur native, for what is called native nickel is combined with cobalt and arsenic, which destroy its malleability and magnetic property. This metal is extremely scarce compared with gold, silver, or copper, but it is truly remarkable, that almost all the meteoric stones, and all the masses of meteoric-iron that have yet been analysed contain nickel. (See METEORIC STONES, Appendix to Book I.) Were nickel plentiful, its uses in the arts and in domestic economy would be numerous. The small proportion of nickel combined with meteoric-iron, preserves the latter metal from oxidation; hence it has been suggested, that a small alloy of nickel, might greatly improve the quality of iron and steel. The ores of nickel communicate a green colour to nitric or nitro-muriatic acid.

SP. 1. COPPER-NICKEL, *Nickel Arsenical*, Haüy.—The colour is a pale copper-red, with a greyish or yellowish tinge; the lustre is metallic. The specific gravity is from 6.60 to 7.50; it yields with difficulty to the knife, and is brittle; the fracture is granular or conchoidal. This ore occurs massive, also botryoidal and in capillary crystals. Before the blow-pipe it yields arsenical vapours, and fuses into a dark slagg, which contains metallic grains. It dissolves in nitro-muriatic acid, and the solution is deep grass-green; caustic alkali throws down a pale green precipitate. Copper-nickel contains—Nickel 44, Arsenic 55. Stromeyer. This ore occurs in veins in some of the mines of Cornwall, and has been found in Saxony, Bohemia, and other mining districts in Europe, and in some parts of the United States.

CAPILLARY COPPER-NICKEL, called by some mineralogists native-nickel, occurs in filaments, adhering to massive copper nickel; the colour is yellowish, inclining to steel-grey.

Sp. 2. NICKEL-OCHRE, *Nickel Oxydé*, Haüy, occurs earthy and pulverulent, incrusting copper-nickel; the colour is apple-green or greenish-white; it is also found massive. It is light and meagre to the touch. It is infusible before the blow-pipe, but melts with the addition of borax into an orange-red glass. Nickel-ochre generally accompanies copper nickel.

Black Ore of Nickel occurs in masses, disseminated, and incrusting other ores of nickel. The colour is dark greyish-black, inclining to brownish-black; it is dull and soft, and has an earthy fracture, but becomes shining and resinous in the streak; it soils the fingers slightly. Black ore of nickel is supposed to be formed by the decomposition of copper nickel. It dissolves in nitric acid, forming a green-coloured solution.

Genus VIII. — LEAD.

Sp. 1. *Sulphuret of Lead, or Galena.*
Supersulphuret of Lead.
Blue Lead Ore.
2. *Triple Sulphuret of Lead.*
3. *Oxide of Lead.*
Black Lead Ore.
4. *Carbonate of Lead.*
Sp. 5. *Muriate of Lead.*
6. *Sulphate of Lead.*
7. *Phosphate of Lead.*
Brown Phosphate.
Arseniated Phosphate.
8. *Arseniate of Lead.*
Reniform-Arseniate.
9. *Chromate of Lead.*
Green Chromate.
10. *Molybdate of Lead.*

Lead has never been found native, unless we except the particles of metallic lead, which, according to Brongniart, are said to be imbedded in lava, in the island of Madeira.

Lead occurs combined with sulphur, with oxygen, and with various acids, forming a great variety of ores. The sulphuret is by far the most abundant ore of lead; it often contains a small quantity of other ores, particularly of silver; indeed there is scarcely an instance of this ore being unmixed with silver, and the latter metal is frequently found in a sufficient quantity to repay the expense of extracting it. This is the case with the lead-ore from many of the mines in Durham, Northumberland, and Yorkshire. The almost constant occurrence of silver with lead, is a fact well deserving attention: Does it not indicate that these metals have one common origin, and are composed of the same elements, combined in different proportions (see page 183.) The ores of lead generally occur in veins, accompanied with calcareous spar, sulphate of barytes, and quartz; they are sometimes found in beds, or disseminated in rocks. The veins which contain lead, traverse both stratified and unstratified rocks. The most productive lead veins in England intersect mountain lime-stone, that alternates with sand-stone, or grey-wacke-slate, in the counties of Northumberland, Durham, Cumberland, and Yorkshire. Lead veins occur in similar lime-stone in Wales and Derbyshire, but the mines of that county are now much less productive than formerly.* In some rare instances, the lead veins penetrate the coal strata which cover the limestone. Ores of lead occur in almost all the principal mining districts in Europe, but according to Patrin, the ores of this metal are extremely rare in Northern Asia, and we are only acquainted with a few mines of lead in the whole of Southern Asia and the Indian islands. Lead-mines are worked in Massachusetts and Pennsylvania, in the United States of America, and there are mines of lead in New Spain and in Chili. The metallic lustre of sulphuret of lead, and its easy reduction, probably occasioned the discovery of this metal at an early period. The lead-mines of Derbyshire were worked by the Romans in the time of Vespasian. According to Pliny, *Plumbum* designated both tin and lead; the former was distinguished by the epithet *album*, white. The different ores of this genus are too dissimilar to be characterised by any one physical property. Most of the ores of lead are easily reducible to the metallic state on charcoal, when placed before the blow-pipe, but some of them require the addition of borax, and yield only minute globules of metal. The oxide of lead gives a yellow colour to glass.

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* For an accurate account of the present state of the Derbyshire lead-mines, see Farey's Survey of Derbyshire, vol. i.

Sp. 1. SULPHURET of LEAD, or GALENA, *Plomb Sulfuré*, Haüy.—The colour is lead-grey, sometimes inclining to steel-grey; the lustre metallic, and varying from splendent to glistening. It occurs in amorphous masses, crystallized, and disseminated. The structure is laminar, granular, or nearly compact. The specific gravity is about 7.50; it yields to the knife, and is sectile. Before the blow-pipe on charcoal, it decrepitates and melts, emitting a sulphureous odour, and globules of metallic lead are formed on the surface of the charcoal. The constituent parts vary in their proportions; one ore from Durham, analysed by Dr. Thompson, contained Lead 85.13, Sulphur 13.2. The impure varieties contain calcareous earth and silex. The proportion of silver varies from a few ounces in the ton, to 60 or 70 ounces; those in which it exceeds 25 ounces, are considered as rich in silver. Galena crystallizes in cubes and octahedrons; the cube is the primitive form; the secondary forms are generally modifications of the cube, or octahedrons. It breaks with ease, and the fragments are cubical. Massive galena is either laminar, granular, compact, or radiated.

Laminar Galena is the most common variety of this species; the laminæ are either straight or curved.

Granular Galena, or Steel-grained Lead-ore, is either coarsely or finely granular; the colour varies from steel-grey to pale lead-grey, and the lustre is splendent or glistening. This variety is often rich in silver.

Compact Galena.—The pale lead-grey galena passes from finely granular, into compact; it is more sectile than the preceding varieties; the fracture is even, passing into conchoidal.

RADIATED or FIBROUS GALENA generally contains antimony and silver; it occurs in flat plates or fibres, which are either diverging or plumose.

SUPER-SULPHURET OF LEAD has a blueish-grey colour, and is earthy; it burns with a blue flame, like sulphur, when exposed to the flame of a candle; it is found at Dufton-Fell in Westmoreland.

BLUE LEAD.—The colour is between a dark indigo-blue and lead-grey; the lustre is metallic and faintly glimmering: it occurs massive and crystallized in small six-sided prisms, which have a rough and dull surface. It is soft and somewhat sectile. The specific gravity is 5.46. This ore is rare; it has been found at Huelgoet in France, at Zschoppen, and in Saxony. It is considered as an intermixture of phosphate and sulphuret of lead. It yields a sulphureous vapour before the blow-pipe, and forms metallic lead.

SP. 2. TRIPLE SULPHURET OF LEAD, *Bournonit.*—The colour is between lead-grey and steel-grey; the lustre shining and metallic. It occurs in masses, disseminated, and crystallized in cubes, which are generally truncated on the angles or edges; it yields to the knife, and is brittle and easily frangible. The specific gravity is 5.70. This ore decrepitates before the blow-pipe, emitting a white vapour, and forms a globule of copper, incrusted with sulphuret of lead. It contains—Lead 42.62, Antimony 24.23, Copper 12.80, Iron 1.20, Sulphur 17. Hatchett. This ore was first discovered near Endellion, in Cornwall; it has since been found in Saxony and other parts of the continent of Europe. I have observed rich antimonial lead-ore disseminated in chlorite, in the rocks at the head of Buttermeer Lake.

Sp. 4. OXIDE OF LEAD, or NATIVE MINIUM, *Plomb Oxydé Rouge.* — This is a scarce ore of lead; its colour is scarlet; it occurs pulverulent, and incrusting sulphuret of lead, in some of the mines in Craven, in Yorkshire. Its properties are the same as the common red-lead of commerce.

Black Ore of Lead occurs incrusting other ores of lead, and sometimes amorphous; its colours are grey, or yellowish or reddish-brown; it is opaque and dull, but sometimes contains an admixture of shining particles of other ores of lead. It is soft or friable. It contains—Oxide of Lead 66, Carbonic Acid 12, Water 2.5, Silex 10.50, Alumine 4.75, Iron and Manganese 2.25.

Both red and black lead-ore are probably derived from the decomposition of sulphuret of lead.

Sp. 4. CARBONATE OF LEAD, *Plomb Carbonaté.*—The prevailing colours of this ore are greyish or yellowish-white, it is sometimes smoke-grey, or tarnished externally brown or green, by the oxides of iron or copper. It varies from translucent to transparent; the lustre is adamantine or resinous, and is glistening or splendent. The transparent varieties are doubly refractive. The specific gravity varies from 6.50 to 7.20; it is soft and extremely brittle. Before the blow-pipe, it decrepitates and melts into a metallic globule. Carbonate of lead occurs crystallized, fibrous, laminar, and compact.

Crystallized Carbonate of Lead. — The primitive form, according to Haüy, is a rectangular octahedron; the angle formed by the incidence of the two broader planes at the summit is 61° 56′, and by the two narrower 70° 30′. Haüy enumerates twelve secondary forms; they are commonly six-sided prisms or six-sided pyramids, variously modified. One variety, the *sex-octonal*, is represented Plate V. fig. 19. The crystals are generally small, with smooth splendent faces.

Fibrous Carbonate of Lead occurs in long acicular prisms, sometimes detached, but more frequently aggregated either parallel or diverging. The lustre is shining and pearly.

Laminar Carbonate of Lead is composed of thin laminæ or scales.

Compact Carbonate of Lead has generally a yellowish-white colour and waxy lustre, and is nearly opaque. It is sometimes soft and almost friable, and is called earthy carbonate of lead. Many of the varieties of carbonate of lead have a near resemblance to sulphate of barytes, and were mistaken for it by the Derbyshire miners so late as the year 1807, and there is reason to believe that very large quantities of this ore were formerly thrown away in that county. Compact carbonate of lead is found in considerable quantities at Grassington in Craven, Yorkshire.

Distinctive Characters. — Carbonate of lead is distinguished from carbonate of lime, and sulphate of barytes, by its greater specific gravity, and easy reduction to the metallic state on charcoal. It is almost instantly changed to a black colour, by touching it with a moistened alkaline sulphuret; and if it remain in a solution of alkaline sulphuret, it acquires a metallic coating of sulphuret lead. This ore is not uncommon in small quantities in many of the English lead mines.

SP. 5. MURIATE OF LEAD, *Plomb Muriaté.*—The colour is pale-grey, passing into pale-yellow; it is transparent or translucent, and generally occurs crystallized in rectangular four-sided prisms, which are often truncated on the edges, and sometimes terminated by four-sided pyramids. The structure is laminar in a direction parallel to the faces of a rectangular prism; the cross fracture is conchoidal. The internal lustre is splendent and adamantine. The specific gravity is 6.05; it is soft and sectile, and easy frangible. It contains—Oxide of Lead 83.5, Muriatic Acid 8.5, Carbonic Acid 6.5. Klaproth. Before the blow-pipe it melts into an orange-coloured globule, and if the heat be continued, it becomes white, the acid flies off, and a globule of metallic lead remains.

This is a scarce ore of lead; it was found formerly near Matlock; there is a large well-defined crystal from thence in the British Museum; it is a rectangular prism terminated by a low four-sided pyramid, set on the lateral planes. Muriate of lead has been found at Hausbaden, near Badweiller, in Germany, and at Southampton lead-mines in the United States.

SP. 6. SULPHATE OF LEAD, *Plomb Sulfaté.*—The colours are light-grey, yellowish-grey, and smoke-grey; it occurs crystallized, disseminated, and amorphous. The crystals are small and shining irregular octahedrons, or forms derived from the octahedron, one of which is represented Plate V. fig. 20. Sulphate of lead varies from transparent to translucent. It is soft, yielding to the nail. The cross-fracture is conchoidal, and the lustre splendent and adamantine. Before the blow-pipe it melts, and is soon reduced to a metallic state. The specific gravity is from 6.30 to 6.70. Its constituent parts are — Oxide of Lead 70.50, Sulphuric Acid 25.75, Water of Crystallization 2.25. Klaproth. It is found at the Parys mine in Anglesea, and in some of the mines of Cornwall, and at Wanlockhead and Lead-hills in Scotland.

Sp. 7. PHOSPHATE of LEAD, or GREEN LEAD ORE, *Plomb Phosphaté.* — The prevailing colours are olive-green and whitish-green; it also occurs grass-green and yellow. It is found amorphous, reniform, and botryoidal; also crystallized in small regular hexahedral prisms, which are sometimes truncated on the edges, or are terminated by obtuse six-sided pyramids set on the lateral planes. The surfaces of the crystals are smooth and shining. The internal lustre is glistening and resinous; they are more or less translucent. Phosphate of lead yields easily to the knife, and is brittle and easily frangible. The fracture is granularly uneven, passing into splintery or conchoidal. The specific gravity varies from 6.20, to near 7. It dissolves in acids without effervescence; it is not reduced to the metallic state on charcoal without borax, with which it forms minute globules of lead. When fused without borax, it forms polygonal globules, that are not metallic. Phosphate of lead contains — Oxide of Lead 80, Phosphoric Acid 18, Muriatic Acid 1.02, Oxide of Iron a trace.

Brown Phosphate of Lead is of a hair-brown colour, passing into lead-grey. It occurs massive and in six-sided prisms, and also pyramidal. The surface of the crystals is blackish and rough; the internal lustre is glistening and resinous. Before the blow-pipe it melts into a globule, which presents a fibrous radiated structure when cooled. Phosphate of lead occurs in many of the lead-mines in the northern counties of England, and in Derbyshire. The brown phosphate occurs in Hungary and Saxony.

ARSENIATED PHOSPHATE OF LEAD, *Fibrous Phosphate of Lead*, J. — The colours are yellowish-green or brown, and the structure fibrous and radiated.

CONCHOIDAL ARSENIATED PHOSPHATE OF LEAD. — The colours incline to yellow and red; it occurs in all the forms of phosphate of lead; the fracture is conchoidal. It contains — Oxide of Lead 76, Phosphoric Acid 13, Arsenic Acid 7, Muriatic Acid 1.75, Water.

SP. 8. ARSENIATE OF LEAD, *Plomb Arsenié*. — The prevailing colour is pale-yellow, inclining to brown, sometimes tarnished externally; it varies from translucent to opaque; the lustre is resinous, and shining or glistening. It occurs in hexagonal prisms, the external lustre of which is unequal, and they frequently become narrower towards the base; the cross-fracture is uneven; it yields to the knife, and is easy frangible. Arseniate of lead occurs also in capillary fibres, compact, disseminated, and reniform. Before the blow-pipe on charcoal, it emits arsenical vapours, and is reduced to metallic lead. The specific gravity is 5. to 6.40. It contains — Oxide of Lead 69.76, Arsenic Acid 20.4, Muriatic Acid 1.58. It occurs in some of the mines of Cornwall and Devonshire. The Cornish arseniate of lead occurs in hexahedral prisms, and bears a considerable resemblance to the darker varieties of carbonate of lead, but is distinguished by its crystallization, and the arsenical vapours which it exhales before the blow-pipe.

The **Reniform Arseniate** has a brownish-red colour, a conchoidal fracture, and a glistening resinous lustre. The specific gravity of this variety is 3.9. It contains — Oxide of Lead 25, Iron 14, Silver 1.15, Arsenic Acid 25, Silex 7, Alumine 2. It is found at Nortschink in Siberia.

Sp. 9. CHROMATE of LEAD, *Plomb Chromaté*, Haüy. —The colour is deep orange-red, but when pulverized orange-yellow. This ore of lead is generally crystallized and translucent; it sometimes occurs in thin plates or amorphous. The primitive crystals, according to Haüy, is a short oblique prism, in which the proportion of the sides to the height is as 23 to 9. Sometimes the prisms are terminated by four-sided pyramids, set on the lateral edges. Sometimes the angles or edges are truncated. The surfaces of the crystals are either smooth or streaked, and are splendent; the structure is distinctly laminar. The cross fracture is uneven and splendent. The specific gravity is from 5.75 to 6.03. It is soft and easily frangible. Chromate of lead contains — Oxide of Lead 64, Chromic Acid 36. Vauquelin.

Distinctive Characters. — This ore may be distinguished from all other red metallic ores, by its tinging borax green before the blow-pipe; it is also reduced to a metallic state on charcoal. Chromate of lead is found at Berezoff in Siberia. It is used as a pigment, forming a beautiful orange-yellow colour.

There is a green or yellowish-green coloured mineral sometimes accompanying the chromate of lead, which is supposed by Vauquelin to be a mixture of the oxides of lead and chrome; it is called by Brongniart *Plomb Chromé.* It communicates an orange-red colour to nitric acid.

SP. 10. MOLYBDATE OF LEAD, *Plomb Molybdaté.* — The colour is wax-yellow, lemon-yellow, or yellowish-brown; it is translucent or transparent; it occurs crystallized and cellular, and incrusting other minerals. The primitive form, according to Haüy, is an octahedron, with equal and similar isosceles triangular faces; the incidence at their neutral base being 76°40′. It occurs also in four-sided prisms, and in tabular crystals; two of the secondary forms are represented Plate V. fig. 21. and fig. 22. The structure is imperfectly laminar, the cross-fracture uneven, passing into conchoidal, with a glistening resinous lustre. It is composed of Oxide of Lead 58, Molybdic Acid 38, Oxide of Iron 2.50. Hatchett. Molybdate of Lead decrepitates before the blow-pipe, and melts into a greyish-coloured slagg, containing globules of metallic lead. With borax, it forms a yellowish globule; and with a greater proportion of borax, a blue or greenish glass. This ore is found with other ores of lead at Bleiberg in Carinthia, and in the Tyrol, in Austria, and Transylvania. It has also been found in Mexico, and in Pennsylvania, and Massachusetts.

Genus IX. — IRON.

- Sp. 1. *Native Iron.*
  - *Meteoric Iron.*
- 2. *Iron Pyrites.*
  - *Radiated Pyrites.*
  - *Hepatic Pyrites.*
  - *White Iron Pyrites.*
- 3. *Magnetic Pyrites.*
- 4. *Magnetic Iron Ore*
  - *Iron Sand.*
- 5. *Iron Glance.*
  - *Specular Ore, or Volcanic Iron.*
  - *Micaceous Iron Ore.*
- 6. *Red Iron Ore.*
  - *Compact.*
  - *Fibrous.*
  - *Scaly or Laminar.*
  - *Ochrey.*
- 7. *Brown Iron Ore.*
  - *Compact.*
  - *Crystallized.*
  - *Fibrous.*
  - *Scaly.*
  - *Ochrey.*
- Sp. 8. *Black Iron Ore.*
  - *Compact.*
  - *Fibrous.*
  - *Ochrey.*
- 9. *Clay Iron Stone, or Earthy Oxide of Iron.*
  - *Nodular.*
  - *Columnar.*
  - *Pisiform.*
  - *Lenticular.*
  - *Jaspery.*
  - *Bog Iron Ore.*
  - *Pitchy Iron Ore.*
  - *Umber.*
- 10. *Yenite.*
- 11. *Carbonate of Iron.*
- 12. *Phosphate of Iron.*
- 13. *Chromate of Iron.*
- 14. *Arseniate of Iron.*
- 15. *Muriate of Iron.*
- 16. *Sulphate of Iron.*

IRON is the most abundant, and the most universally distributed of all metallic substances; it may be said to form a principal constituent part of the globe itself, as it enters into the composition of almost all the rocks and strata that environ its surface. Entire strata, and even mountains, are formed of iron-ore; it occurs also in veins, and is associated with the ores of other metals. Iron abounds in the stony matter ejected from volcanoes, and is found in the most recent alluvial soil. This metal has however been seldom discovered native in mines, as it oxidates rapidly, when exposed to air or water. It has sometimes been found in masses of considerable size, on the surface of the earth; most, if not all of these masses are meteoric, having fallen from the atmosphere at different periods, attended with the same phenomena, that accompany the fall of meteoric stones.

A portion of metallic iron is likewise found in almost all the meteorolites that have yet been analysed. (See METEORIC STONES, page 495.) Iron occurs in the state of ore combined with oxygen, with sulphur, or with various acids.. In these combinations it is often united with other metals in such a proportion, as to make it doubtful to which species the ore properly belongs. Every species of iron-ore attracts the magnetic needle, when deprived of part of its oxygen by roasting, and afterwards mixing it with tallow or wax, and exposing it to the flame of the blow-pipe on charcoal; indeed all rocks or minerals that contain any notable portion of iron, become magnetic when treated in the same manner. The ores of iron communicate a dark olive-green colour to borax; this distinguishes them from the ores of cobalt, which give a blue colour; and from the ores of manganese, which give a purple colour; or from ores of nickel, which give a bright-green colour. The two metals, cobalt and nickel, are also magnetic, but in a less degree than iron. The uses of iron are too numerous to admit of their enumeration in the present volume.

Sp. 1. NATIVE IRON is said, in a few rare instances, to have been found in veins either in branches or stalactitical, also cellular and amorphous. The places which are mentioned as affording native iron are — Kamsdorf, Steinbach, and Ebestock in Saxony, and in the vicinity of Grenoble. It is also found in the lavas of some volcanoes. The native iron from Kamsdorf contained — Iron 92.50, Lead 6, Copper 1.50. Klaproth. This iron is rather lighter coloured than common iron.

Meteoric Iron. — The colour is pale steel-grey, inclining to white, like platina; it is generally coated externally with a brown incrustation of oxide of iron; internally the lustre is metallic, and is splendent when scratched. It yields to the knife, and is malleable and flexible. The specific gravity varies from 6.48 to 7.57. Meteoric iron is composed of pure iron, with a portion of nickel varying from 1.5 to 11 parts in the 100. Many specimens of meteoric iron are placed with meteoric stones in the collection at the British Museum; among others there is a small specimen of the iron that fell at Agram in Croatia, on the 26th of May, 1767. A luminous meteor was observed to explode with a tremendous report, and two masses of iron fell from it, the one weighing 71 lbs. the other 16 lbs.

The largest is in the Imperial Cabinet of Vienna. A mass of native iron, containing nickel, was discovered in the district of St. Jago del Estro in South America; it is supposed to weigh 30 tons. Meteoric iron does not oxidate by exposure to the air like common iron. See NICKEL.

SP. 2. IRON-PYRITES, SULPHURET OF IRON, *Fer Sulphuré*, Haüy.—This is one of the most common ores of iron, being found in almost all rocks from granite to chalk, either disseminated or in veins. Its colour is generally brass-yellow, passing into pale-yellow or steel-grey. The lustre is metallic, of different degrees of intensity, from splendent to glistening. Iron-pyrites occurs massive, disseminated, and crystallized. The crystals are generally cubes or octahedrons, often variously modified. According to Haüy, the cube is the primitive form, but according to Bournon, the octahedron. Haüy has enumerated 27 varieties of secondary forms, one of which has 135 faces. The following are the most remarkable crystallization of this mineral. Plate V. fig. 6. represents the striated cube, the striæ of the adjoining faces are perpendicular to each other. *Fer sulphuré tryglyphe*, (fig. 7.) a cube truncated on all its edges; *cubo-dodecahedre*, (fig. 8.) an icosahedron with eight equilateral and twelve isosceles triangular faces; (fig. 9.) a solid bounded by 30 faces, of which 6 are rhombs, and 24 are trapeziums, *tricacontadre*; (fig. 10.) the *pantagone*; (fig. 11.) the *surcomposé*. The specific gravity of iron-pyrites extends from 4.60 to 4.83. The hardness of this ore exceeds that of almost all metallic minerals; it resists the point of a knife; this serves to distinguish it from copper-pyrites: it even gives sparks with steel, and emits at the same time a sulphureous odour. Iron-pyrites breaks with some difficulty; the fracture is uneven and granular, but sometimes nearly compact, passing into conchoidal; it is not sectile like copper-pyrites. Before the blow-pipe it emits a sulphureous odour, and melts into a brownish-coloured globule, which is attracted by the magnet. Iron-pyrites contains — Iron 47.85, Sulphur 52.15. (Hatchett.)

Iron-pyrites also occurs radiated and cellular, stalactitical, &c.

Radiated Pyrites is met with in globular or cylindrical concretions, which are composed of prisms, adhering and radiating from a centre; these concretions are very common in the lower chalk, near Dorking in Surrey. Radiated pyrites is more liable to decomposition than common pyrites, which M. Hatchett, in his valuable account of pyrites, is inclined to attribute to a certain degree of oxidation of the sulphur, at the time of the original formation of these concretions. Phil. Trans. 1804.

Hepatic Pyrites, or Liver Pyrites.—This variety acquires a liver-brown colour by exposure to the atmosphere, whence its name is derived. Internally the colour is a pale-yellow, passing into a steel-grey.

White Iron Pyrites has a yellowish or tin-white colour; according to the analysis of M. Hatchett, it contains—Iron 45.46, Sulphur 54.34.

Pyrites frequently occurs in crystals, and incrusting organic remains in the argillaceous lime-stone called lias. It is found in all meteoric stones. In one which fell at Weston in Connecticut, in 1807, two cubic crystals were discovered, two-thirds of an inch in diameter. (Bruce's Min. Journ. vol. i.) Iron Pyrites sometimes undergoes a rapid decomposition on exposure to air and moisture, the sulphur absorbing oxygen combines with the oxide of iron and forms the sulphate of iron, or green vitriol; during the process much heat is evolved; to this cause, the spontaneous combustion of beds of coal is sometimes owing, in coal mines that abound in pyrites.

Sp. 3. MAGNETIC PYRITES contains a smaller portion of sulphur than common pyrites, to which it owes the property of being attracted by the magnet. As M. Hatchett has shown, that when sulphur is combined naturally or artificially with iron, in the proportion of 37 parts in the hundred, it is still capable of receiving and retaining the magnetic property, so as to remain permanently magnetic. The colour of magnetic pyrites is bronze-yellow passing to copper-red, or pinchbeck-brown; the lustre is metallic and shining; it occurs amorphous and sometimes crystallized in hexagonal prisms: its fracture is uneven passing into conchoidal. It affects the magnetic needle. It contains—Iron 63.5, Sulphur 36.5. Hatchett.

Magnetic Pyrites is found only in the lower or primary rocks, and is accompanied with common pyrites. It has been found on the base of Moel Elion, a mountain in Caernarvonshire, and in various parts of Europe. Magnetic pyrites is a sulphuret of iron, and common pyrites is a supersulphuret; neither of these species are worked as ores of iron; the latter is employed in the manufacture of green-vitriol.

Sp. 4. MAGNETIC IRON-ORE, *Fer Oxydulé.* — This ore occurs massive, forming entire beds in mountains of gneiss, mica-slate, chlorite-slate, and clay-slate; and is sometimes disseminated in granite, green-stone, and other rocks. It is accompanied by iron-pyrites and other metallic ores, and frequently contains garnets and other minerals. Magnetic iron also occurs crystallized in octahedrons and dodecahedrons, also rhomboidal. The regular octahedron is the primitive form. The colour of this ore is iron-black; the lustre metallic and shining, or nearly dull; the streak and powder are brownish-black; the fracture is uneven or small conchoidal; and the lustre of the fresh surface shining and metallic. It yields to the knife, and is brittle. The specific gravity varies from 4.20, to 5.00. Before the blow-pipe it becomes brown, and does not melt, but with borax it forms a dark-green slagg. This ore is magnetic, and has two or more poles which alternately attract and repel the magnetic needle. According to an analysis of Berzelius, magnetic iron-ore contains iron in two states of oxidation. The Protoxide, or Black Oxide 28.14, the Peroxide, or Red Oxide 71.86. A variety of compact magnetic iron ore contained Protoxide of Iron 78, Oxide of Titanium 22. The magnet belongs to this species, possessing the highest degree of magnetic polarity. Magnetic iron occurs in immense quantities in Sweden and Norway, and is worked as a valuable ore of iron; it is found also in various parts of Europe, Asia, and America. Magnetic iron-ore occurs in some parts of Cornwall, and near Tavistock in Devonshire.

Iron-Sand, *Fer Oxydulé Titanifere.* — This ore occurs in grains and octahedral crystals, imbedded in lava and in basaltic rocks; it is also found in the sands of rivers. The colour is iron-black; the surface is rough and glimmering internally; the grains are shining and metallic; the fracture is generally conchoidal. It yields to the knife. The specific gravity is from 4.60 to 4.76. It is attracted by the magnet. It contains — Oxide of Iron from 79 to 82, Oxide of Titanium 15.9 to 12.6. Oxide of Manganese 2.5 to 4.5, Silex and Alumine 1 to 0.6. Cordier. Iron-sand, from the river Dee, Aberdeenshire — Oxide of Iron 85.3, Oxide of Titanium 9.5, Arsenic 1, Silex and Alumine 1.5. Thompson.

Iron-sand, according to the observations of Cordier, is a constituent part of all dark-coloured lavas and basalts, and may therefore occur in all volcanic and basaltic countries. It has been found in the sands of the river Mersey in Lancashire, at Hunstanton in Norfolk, and in various parts of Cornwall.

Earthy Magnetic Iron-Ore occurs in rolled pieces in the iron mines of Arendal in Norway, and appears to be common magnetic iron-stone in a state of decomposition. Its colour is bluish-black; it soils the fingers, and is soft. The specific gravity is 2.20.

The following species of iron-ore, iron-glance, red iron-ore, brown iron-ore, black-iron ore, and clay-iron-stone, with all the varieties of earthy ores of iron, are essentially composed of iron combined with oxygen. In some of these, the oxide of iron is further combined with carbonic acid, or with water. All the ores above mentioned, except the two first, are classed by Haüy under one species — Oxide of Iron, *Fer Oxydé*. It is greatly to be regretted that the analyses of these most useful ores are at present so incomplete. The scientific professors at universities and public establishments, who have ample means for such investigations, and are rewarded by the public for their time, find more celebrity is to be acquired by the analysis of rare substances, of no use in the arts, nor of any importance in the economy of nature, than by the examination of common minerals of the highest service to mankind. With respect to one species of iron-ore, the sulphuret, the valuable labours of Mr. Hatchett have left us little to desire.

Sp. 5. IRON-GLANCE, *Eissenglanz*, Werner, *Fer Oligiste*, Haüy. — The colour is steel-grey, sometimes passing into iron-black, and sometimes inclining to red. The surface is often tarnished blue, yellow, or green. It is opaque, except in thin fragments or near the edges; the transmitted light is red; the powder and streaks are also red. The lustre is metallic, and frequently highly splendent. The specific gravity is about 5, and the hardness of some of the varieties sufficient to scratch glass. Iron-glance is more or less magnetic, but does not attract iron-filings. It is infusible before the blow-pipe, and insoluble in nitric acid. Iron-glance occurs massive, disseminated, and crystallized, in polished plates, and in minute laminæ or scales.

MASSIVE IRON-GLANCE has sometimes an uneven or conchoidal fracture, sometimes the laminar structure is distinct. This ore occurs in immense beds and veins in primitive mountains, associated with other ores of iron.

CRYSTALLIZED IRON-GLANCE occurs sometimes in rhombs, which approach nearly to the cube. The angles formed by the incidence of the planes are, according to Haüy, 87° 9′ and 92° 51′. This is the primitive form, and is obtained from some of the massive varieties by cleavage. Haüy has enumerated sixteen secondary forms. One of these, composed of six pentagonal faces, six isosceles triangles, and twelve scalene triangles, is represented Plate V. fig. 12. *Binoternaire.* This form is common to the splendent crystals from the Isle of Elba, which are generally aggregated in groups, and highly irridescent. Another form (fig. 13.) is composed of two hexahedral pyramids, and deeply truncated on the summit. — *Trapezien.* The same variety, truncated on the solid angles at the common base, is represented fig. 14. *Progressif.* The lenticular variety is formed by a compressed rhomboid, with the angles and edges truncated. The structure is distinctly laminar, with a cleavage parallel to the planes of the primitive rhomb. The cross-fracture is granular, and the lustre glimmering. The specific gravity is about 5. Crystallized iron-glance occurs in cavities of the massive variety, and is particularly beautiful in the mines of the Island of Elba.

Specular Iron, or Volcanic Iron, has the brilliancy of polished steel; it occurs in thin plates bevelled on the edges, and sometimes in very compressed octahedrons. It is found in the craters of volcanoes, particularly in Vesuvius and Stromboli, also in Auvergne. The fracture is conchoidal and shining; it has the same primitive form as the preceding variety. The specular iron from Stromboli and the Lipari Island is far more brilliant than that from Vesuvius, and occurs in large plates which reflect nearly as much light as the most highly-polished mirror. The hardness is sufficient to scratch glass, and it acts powerfully on the magnetic needle.

Micaceous Iron-Ore, Iron-Mica.—This ore occurs in minute scales, which are loosely adhering or disseminated; the colour is iron-black; the lustre shining or glistening and metallic. By transmitted light the colour is blood-red. It is found in considerable quantities near Tavistock in Devonshire, and occurs also near Dunkeld in Perthshire, with chlorite and quartz.

Iron-glance is a peroxide of iron, containing about 10 or 12 parts in the 100 of other ingredients, and by a late analysis of Berzelius, it appears that the Elbese iron-glance contains an admixture of titanium. The formation of specular iron-ore, in the craters of volcanoes, is illustrated by the observations of St. Fond and M. M. de Larbre, who discovered that this ore is sublimed in the fissures of the pots in glass furnaces, when the clay, of which these pots are made, contains pyrites.

Sp. 6. RED IRON-ORE, RED HEMATITE. — The varieties of this ore are classed, by Haüy, with the preceding species, *Fer Oligiste.* They probably contain the same constituent parts intermixed with earthy matter, which generally diminishes, more or less, the specific gravity and hardness, and renders the lustre less metallic. According to Haüy, the more pure part of the ore is sometimes crystallized, and has the same primitive form as the preceding species, but the difference before mentioned, in hardness, specific gravity, and lustre, and the uncertainty that prevails with respect to the exact proportion of the constituent parts in these ores, induce me to continue their separation into two species. Red iron-ore occurs compact, fibrous, in laminæ, and earthy, or in ochre.

COMPACT RED IRON-ORE, *Fer Oxydé Rouge Compact.* Brongniart. — It occurs massive in beds and in veins, associated with other varieties of this species, and sometimes with those of the preceding species, and with quartz, horn-stone, and jasper. It occurs also disseminated and in crystals, which are supposed to be supposititious. The colour is between steel-grey and brownish-red; the lustre is shining or glimmering, and varies from semi-metallic to metallic; sometimes the surface is smooth, specular, and splendent. The colour of the powder is blood-red; the fracture is granular, even, or conchoidal. The hardness is variable, but it yields to the knife; the specific gravity extends from 3.50 to 5.

FIBROUS RED IRON-ORE, RED HEMATITE, *Fer Oligiste Concretioné.* — This ore occurs with the preceding in globular or kidney-shaped masses; also botryoidal and stalactitical; its colour is between brownish-red and blueish steel-grey or dark steel-grey; the lustre is glimmering and metallic. The structure is fibrous and radiated in one direction, and curvedly laminar in the other, being composed of concentric layers; the colour of the streak and powder are blood-red. The specific gravity is about 4.70. According to Daubuisson, it contains — Oxide of Iron 94, Silex 2, Water 2.

RED SCALY OR LAMINAR IRON-ORE has a brownish-red colour inclining to steel-grey, and a glimmering semi-metallic lustre; it occurs in loose scaly particles, which feel unctuous to the touch, and leave a blueish-red stain on the fingers. This ore is nearly allied to micaceous iron-ore, and appears to form the passage from that ore into red ochre. It contains, according to Haüy — Iron 66, Oxygen 28.50, Silex and Alumine 5.50. The three preceding varieties of ore occur in beds of considerable magnitude, near Ulverstone in Lancashire; they yield the most ductile and malleable iron, suited for the wire-drawer. They are also sent to other parts of England, and smelted with clay iron-stone, to improve the quality of the metal. Red iron-ore is found in Cumberland, Devonshire, and some parts of Scotland, and in many parts of the continent of Europe.

RED OCHRE. — The colour is pale blood-red or brownish-red: it occurs coating other ores of iron, and also in masses which are friable, being composed of minute particles that have a faint glimmering lustre; it stains the fingers.

RED CHALK, or REDDLE, has a brownish-red colour, and a dull earthy fracture; it is soft and meagre to the touch, and adheres to the tongue. It is obtained in considerable quantities from pits which are at a small depth under the surface of the soil, near Doncaster in Yorkshire. It occurs also in small masses in rocks of clay-slate and lime-stone.

SP. 7. BROWN IRON-ORE, BROWN HEMATITE. — This ore occurs, like the preceding species, either compact, fibrous, in laminæ, or earthy, and also crystallized. It differs from the preceding species in the colour of its powder, which is of a yellowish or blackish-brown colour. Brown iron-ore becomes darker and magnetic before the blow-pipe, but is infusible. It tinges borax olive-green. According to the analysis of Daubuisson, this ore is an hydrate of iron, containing—Peroxide of Iron from 81 to 84, Water from 11 to 12, Oxide of Manganese 1 or 0, Silex 2 to 4. The fibrous variety contained — from 14 to 15 Water, and from 79 to 82 Oxide of Iron.

Brown Iron-ore is found in beds or masses sometimes of great magnitude. It also occurs in veins generally accompanied with calcareous spar, and sulphate of barytes. Brown iron-ores melt easily, and yield from 40 to 60 per cent. of metal.

Compact Brown Iron-Ore. — The colour is olive-brown, sometimes externally tarnished, or bronze-yellow, or greenish; the lustre is glimmering and semi-metallic; it yields without difficulty to the knife; the specific gravity extends from 3.40 to 3.70.

Crystallized Brown Iron-Ore occurs in cubes, rhomboids, pentagonal dodecahedrons, and octahedrons, which are supposed to be formed from other crystals of iron-ore, and not to be genuine crystals. Brown iron-ore also occurs in small short rectangular prisms, that are considered as true crystals.

Fibrous Brown Iron-Ore, or Brown Hematite, occurs olive-brown, dark-brown, or steel-grey, sometimes tarnished externally velvet-black, pinchbeck-brown, or greenish-blue. It is rarely found amorphous, but more frequently stalactitical, botryoidal, reniform, tuberous, or coralloidal; the structure is fibrous and radiated, and in the other direction curvedly laminar. The lustre in the direction of the fibres is glistening and silky; the specific gravity is from 3.78 to 4.02; it yields to the knife.

SCALY OR LAMINAR BROWN IRON-ORE. — The colour is between steel-grey and olive-brown; its other properties are the same as those of scaly red iron-ore.

EARTHY OR OCHREY BROWN IRON-ORE. — The colours are yellowish-brown; the fracture earthy; it is soft, and stains the fingers. It is found at Shotover Hill in Oxfordshire.

BROWN IRON-ORE occurs but in small quantities in any part of Great Britain; but abounds in Bohemia and Saxony; the iron obtained from it is harder than that from the red-ore, and it is said to make excellent steel.

SP. 8. BLACK IRON-ORE? *Swartz Eissenstein.* — It is doubtful whether this be a distinct species, or only the brown iron-ore rendered black by an admixture with manganese. It occurs fibrous, compact, and ochrey, with the same structure and characters as those varieties of brown iron-ore, except that the colour is blueish-black, passing into steel-grey, with an imperfect metallic lustre. From the admixture of manganese, it is said to yield a violet-coloured glass with borax.

SP. 9. IRON-STONE, CLAY IRON-STONE, OR EARTHY OXIDE OF IRON, *Fer Oxydé Massif,* Haüy. —This ore occurs abundantly, forming thin regular strata, which alternate with shale, sand-stone, and coal, in all the principal coal districts in Great Britain. It is the ore from which English iron is principally obtained, but it does not present any metallic character when extracted from the mine. The colours are ash-grey, yellowish-grey, and dark blueish-grey, also brown or reddish-brown; the colours darken by exposure to the air. Iron-stone is dull, and has an earthy appearance and texture: the fracture is even or flat conchoidal. The structure sometimes inclines to slaty. Iron-stone occurs massive, and in kidney-shaped nodules, and impressed with the form of plants, and more rarely of bivalve shells. It yields easily to the knife, and breaks with facility; it feels meagre to the touch, and adheres slightly to the tongue. Iron-stone does not affect the magnetic needle, but it becomes black and highly magnetic before the blow-pipe. Its specific gravity generally exceeds 3. In twelve specimens of the best iron-stone which I examined from different beds in the same coal-field at Ashby Wolds in Leicestershire, four ranged from 2.92 to 2.96, and eight from 3.03 to 3.39. The constituent parts of this ore are various. In some, the iron appears to be in a state of oxide; in others, the oxide is combined with carbonic acid, or with water. As this ore does not affect the magnetic needle, it may be inferred to be in a state of peroxide. The iron-stone from Colebrooke-Dale contained — Oxide of Iron 50, Oxide of Manganese 2.6, Silex 10.6, Alumine 2, Lime 1.6, Magnesia 2.4, Water and Carbonic Acid 32. From Brandau — Oxide of Iron 35, Silex 11, Alumine 20, Magnesia 2, Sulphur 3, Water 10.

NODULAR IRON-STONE, *Ætites.*—Nodular iron-stone often occurs in the soft argillaceous strata that accompany common iron-stone; it is generally richer in iron than the stratified ore. Ætites, or hollow nodular iron-stone, occurs frequently in alluvial soil; the nodules are composed of concentric layers, and often contain a loose rounded nucleus; sometimes the cavity is filled with friable yellow earth.

Columnar Clay Iron-stone occurs in amorphous masses and in rounded pieces, which are composed of prismatic concretions laterally aggregated, and more or less adhering. It is earthy and brittle; sometimes the interstices between the prisms are lined with galena, blende, or calcareous spar.

Pisiform Iron-stone, *Fer Oxydé globuliforme*, Haüy.—This variety consists of spherical grains often the size of a pea. The globules are composed of concentric layers, and are generally united by a ferruginous cement. The colours are reddish or yellowish-brown; it is soft and earthy internally. The specific gravity is 4.24 to 5. It contains—Oxide of Iron 48, Alumine 31, Silex 15, Water 6. Vauquelin. This ore occurs in the upper parts of Ayrshire, and in various parts of the continent of Europe. It yields from 30 to 40 per cent. of iron. It is said to be used for shot by the inhabitants of Dalmatia.

Lenticular Iron-stone occurs in small granular or lenticular concretions aggregated in masses; the colour is reddish or yellowish-brown, and the lustre pseudo-metallic.

Jaspery Iron-stone appears to be formed by a combination or intermixture of iron and siliceous earth; it has a reddish or yellowish-brown colour; it occurs massive; the fracture is flat-conchoidal, passing into even; it yields to the knife, is brittle, and easily frangible.

Bog Iron-Ore.—This ore is found in alluvial soil, or in swamps, and even at the bottom of stagnant pools; its colours are various shades of brown; it occurs in amorphous or rounded masses, which are externally corroded or cellular; it is soft and earthy, but varies from friable to compact; its specific gravity is also variable. It sometimes has a conchoidal fracture, and a resinous lustre. It contains, according to Daubuisson—Peroxide of Iron 61, Oxide of Manganese 7, Silex 6, Alumine 2, Phosphoric Acid 2.5, Water 19. This ore is formed by water depositing the oxide of iron in low situations; as the water gradually evaporates, the ore becomes more and more indurated, and in the different states of induration has been called *friable ore*, *swamp ore*, and *meadow ore*.

Pitchy Iron-Ore has a resemblance to pitch; it is of rare occurrence and of little importance. The colour is black or brownish; the lustre resinous and glistening; the fracture flatly conchoidal or granular; it contains, according to Klaproth—Oxide of Iron 67, Sulphuric Acid 8, Water 25. Its specific gravity is 2.4; it yields to the knife, and gives a yellow-coloured streak; it was formerly found in a mine near Freyberg.

Umber is of a blackish or yellowish-brown colour: the lustre is dull; the fracture earthy; it is soft, meagre, and adhesive. Some of the harder varieties have a faint resinous lustre, and a conchoidal fracture. The specific gravity is about 2.00. It contains—Oxide of Iron 48, Oxide of Manganese 20, Silex 13, Alumine 5, Water 1

Umber is brought from the island of Cyprus, and is used as a pigment. A bed of a mineral possessing most of the characters of umber, occurs in the grounds of Lord Clifford, at Chudleigh in Devonshire.

Sp. 10. YENITE has frequently been classed with earthy minerals; it is properly an ore of iron. Its colours are black, or brownish, or blueish-black; the lustre is glistening or shining, and resinous or semi-metallic; it occurs crystallized and amorphous. The crystals are commonly four-sided prisms, nearly square, and terminated by four-sided pyramids. The lateral planes of the prisms are longitudinally striated, and the edges are frequently truncated. The primitive form, according to Haüy, is a rectangular wedge-shaped octahedron; the angles at the summits in one direction are 112° 36′, and in the other 66° 38′. The structure is imperfectly laminar, parallel to the axis and shorter side of the octahedron; the cross-fracture is uneven or imperfectly conchoidal. The specific gravity is from 3.82 to 4. Yenite scratches glass, but is softer than felspar. It becomes magnetic by heating before the blow-pipe, and melts with intumescence, into an opaque black glass, which is semi-metallic. It contains—Oxide of Iron 49, Oxide of Manganese 2, Silex 30, Alumine 1, Lime 14.5. Yenite occurs in primitive lime-stone in the isle of Elba. There are very distinct prismatic crystals of this mineral in the British Museum.

Sp. 11. CARBONATE of IRON, or SPARRY IRON-ORE. — The colours are yellowish-white or brown; they darken by decomposition; it is translucent or opaque, and has frequently a pearly lustre, varying from glimmering to shining. Carbonate of iron occurs crystallized and amorphous; the crystals are rhomboids, the obtuse angles are 107° (Wollaston); the structure is laminar parallel to the faces of the rhomboid. Sometimes the planes are curvilinear. Carbonate of iron yields easily to the knife; it effervesces in muriatic acid. Before the blow-pipe it becomes magnetic, but does not melt. Some analyses give the contents of this ore — Oxide of Iron 66, Carbonic Acid 34. By other analyses it is found to contain a considerable portion of carbonates of lime and magnesia; indeed this ore differs little from pearl-spar in appearance, and they are supposed to pass into each other. (See PEARL-SPAR.) In one analysis by Bergmann, he discovered 28 parts of lime. The varieties that contain the greatest quantities of iron may be expected to possess greater specific gravity, which is found to vary from 3.30 to 3.90. In some parts of Germany, this mineral occurs in considerable quantities, and is smelted as an ore of iron. It is said to make steel of an excellent quality. The property of becoming magnetic before the blow-pipe may determine the limits between carbonate of iron and pearl-spar.

Carbonate of iron occurs in the fissures of clay-ironstone in Glamorganshire, and also in the mines of Cumberland and Cornwall.

SP. 12. BLUE IRON-ORE, PHOSPHATE OF IRON, *Fer Phosphaté.*—The colour of this ore is indigo-blue or smalt-blue, sometimes inclining to green. The colour resembles that of some of the ores of copper, but it dissolves without effervescence in nitric acid, and does not, like copper ores, form a blue solution, or become blue on the addition of ammonia. Blue iron-ore occurs in small translucent crystals, either oblique four-sided prisms, or six or eight-sided prisms, with dihedral summits; the structure is laminar in one direction, parallel to the axis of the crystal. The prismatic crystals are generally aggregated and diverging. Phosphate of iron, when crystallized, contains — Oxide of Iron 41.25, Phosphoric Acid 19.25, Water 31.25, Ferruginous Silex 1.25, Alumine 5.

Phosphate of iron also occurs massive, with a diverging fibrous structure, at Stavern in Norway, and in West Greenland.

Earthy Phosphate of Iron, *Fer Phosphaté terreux*, occurs in beds of clay, and in alluvial soil and peat. In its original situation it is sometimes blueish-white, but becomes dark-blue by exposure to the air; it occurs in friable masses and incrustations, and is composed of fine dull earthy particles. It contains— Oxide of Iron 47.50, Phosphoric Acid 32, Water 20. In all probability the phosphoric acid found in this ore has been furnished by the decomposition of animal remains. It is found in the mud of rivers, and in peat moors, in various parts of Great Britain.

Native Muriate of Iron, or Pyrosmalite, has been found in one mine near Philipstadt in Sweden; the colour is liver-brown inclining to green; it occurs crystallized in six-sided prisms, which have cleavages parallel to the sides and terminal planes; the lustre is shining and pearly, that of the cross-fracture glimmering. The powder is brownish-white; it is translucent on the edges and brittle. The specific gravity is about 3. It is insoluble in water. Before the blow-pipe, it emits vapours of oxymuriatic acid, and becomes magnetic.

Sp. 13. CHROMATE of IRON, *Fer Chromaté.* — The colour is brownish-black, sometimes inclining to steel-grey; the lustre resinous or semi-metallic, and glistening or shining. Its hardness is greater than that of window-glass. The specific gravity varies from 4 to 4.03. It is infusible before the blow-pipe, but yields a bright-green colour with borax, which distinguishes it from all the other ores of iron, and from the dark varieties of blende.

Chromate of iron occurs amorphous and disseminated, and has also been found crystallized in regular octahedrons, at Bare Hills near Baltimore, in the United States. The crystals have a cleavage parallel to all the faces. They are sometimes translucent, appearing deep-red by transmitted light.

Massive Chromate of Iron has an uneven or compact conchoidal fracture; but some varieties have an imperfect laminar structure. Chromate of iron contains — Oxide of Chrome 43, Oxide of Iron 35, Alumine 20, Silex 2. Vauquelin. Or — Oxide of Chrome 53, Oxide of Iron 33, Alumine 2, Silex 2, Volatile Matter 2. Klaproth. Chromate of iron occurs in grains imbedded in serpentine at Portsoy in Bamfshire, and in the same rock in some of the Shetland Islands. It occurs in France and the Uralian Mountains, and is rather plentiful in part of the United States of America, and is employed to obtain the chromic acid, which forms a beautiful yellow pigment with lead.

Sp. 14. ARSENIATE of IRON, *Fer Arsenié.*—The prevailing colour is a dark brownish-green passing to grass-green and brown. It generally occurs crystallized in cubes which are aggregated; sometimes the angles or edges are truncated; it varies from translucent to transparent. The surface of the crystals are smooth, and have a shining vitreous lustre; the fracture is uneven or imperfectly conchoidal; it is brittle, and yields easily to the knife. The specific gravity is 3. It melts before the blow-pipe, and emits arsenical vapours. It sometimes is decomposed on the surface, and acquires a brownish colour. Arseniate of iron contains — Oxide of Iron 46, Arsenic Acid 18, Water 32. Vauquelin.

This ore has hitherto been principally found in a few mines of Cornwall.

Sp. 15. SULPHATE of IRON, or COPPERAS.— This salt occurs in small quantities, but being soluble in water, will be described in the class of salts.

GENUS X. ZINC.

Sp. 1. *Sulphuret of Zinc, or Blende.*
2. *Calamine.*
Electric Calamine.
Red Calamine.
Sp. 3. *Automalite.*
4. *Sulphate of Zinc.*

Zinc has never been discovered native; it is found combined with sulphur or with oxygen, and also with carbonic and sulphuric acids. The ores of zinc generally accompany the ores of lead in every quarter of the globe; but it is observed by the miners in Derbyshire, that in those parts of the mine where the ores of zinc are plentiful it becomes poor in lead, or the quality is injured; and in the mines that are worked for ores of zinc, when the lead-ore becomes abundant, the ores of zinc are diminished; hence they say, "the lead eats up the calamine." Zinc has been long known as a metal in China and India, yet though one of the ores of zinc was employed by the ancient Greeks in the conversion of copper into brass, the extraction of metallic zinc from its ores is a recent discovery in Europe. Henckel first extracted zinc from calamine about the year 1721. In the year 1743, Mr. Champion, of Bristol, obtained a patent for making zinc; but at a much later period the ores of zinc were so little known, that they were employed for mending the roads, in some parts of Derbyshire.

Zinc is combustible at a temperature below that at which copper melts, and is entirely volatilized, when its ores are smelted in open vessels; hence the method of reducing it to a metallic state remained so long unknown. During the last year, it has been discovered that zinc sometimes contains a small portion of a metal hitherto unknown, and which has received the name of Cadmium.

SP. 1. SULPHURET OF ZINC, or BLENDE, *Zinc Sulphuré.* — This ore occurs yellow, brown, or black, of which some mineralogists make three subspecies, yellow-blende, brown-blende, and black-blende.

Blende occurs in amorphous masses which have a confusedly crystalline structure, also disseminated and crystallized. The lustre varies from resinous to metallic, and from shining to splendent; some varieties are translucent and have an adamantine lustre. The structure is laminar with six distinct cleavages; according to Haüy, the rhomboidal dodecahedron is the primitive form. It occurs also in octahedrons, tetrahedrons, and cubes, variously modified. One dodecahedral variety is represented Plate V. fig. 4. The specific gravity of blende is from 3.7 to 4.0; it yields easily to the knife, which distinguishes it at once from tin-stone. The streak and powder are yellowish-grey, which distinguish it from galena. It is infusible before the blow-pipe, and yields the odour of sulphuretted hydrogen, when powdered and digested in sulphuric acid.

PHOSPHORESCENT BLENDE.—The yellowish and highly splendent and translucent varieties of blende phosphoresce when scraped.

COMPACT OR FIBROUS BLENDE.— A variety of blende occurs in Bresigau, and at Rasbel in Carinthia, which is massive or reniform, and has a fibrous diverging structure in one direction, and is curvedly lamellar in the other. Blende contains — Zinc 50.09, Iron 12.05, Sulphur 28.88. Black-blende from Nagyag contains a minute portion of auriferous silver.

Blende occurs in all the mining districts of England that furnish lead-ore; the brown variety is the most common.

SP. 2. CALAMINE, *Zinc Carbonaté.* — This ore has not the appearance of a metallic mineral. The colours are light ash-grey, yellowish-grey, or greenish-grey, and also brown; the lustre is between resinous and vitreous; it is found crystallized, compact, and earthy.

Crystallized calamine occurs in acute or obtuse rhomboids, and in four-sided tabular crystals, either perfect or variously modified. The structure is imperfectly laminar; it is translucent or transparent. The specific gravity is about 4.30; it yields easily to the knife. It is infusible before the blow-pipe, but loses about 34 per cent. probably water; it dissolves with effervescence in muriatic acid. It contains — Oxide of Zinc 65, Carbonic Acid 35. Smithson.

Compact calamine is opaque, and has generally less lustre than the crystallized; it occurs in stalactitical, reniform, or botryoidal masses, also cellular, and in pseudo-amorphous crystals, and incrusting other minerals. The fracture is granular, splintery, even, or flatly conchoidal.

Earthy calamine is generally greyish or yellowish-white, and is earthy, dull, and soft, yielding to the nail. It contains, according to Smithson — Oxide of Zinc 71.4, Carbonic Acid 13.5, Water 15.1. Its earthy state is probably derived from partial decomposition, and the loss of carbonic acid.

Calamine also occurs in thin aggregated laminæ which have a green colour, supposed to be derived from carbonate of copper.

Sp. 3. ELECTRIC CALAMINE, *Zinc Oxydé.*—This species is so called from its becoming highly electric when gently heated. The colours are greyish, blueish, and yellowish-white, and sometimes green; the lustre shining and vitreous; it varies from transparent to opaque. It occurs amorphous, mamillated, laminar, and crystallized, either in small single crystals, or in radiated groups like zeolite. The crystals are octahedrons or six-sided prisms, often variously modified. One of the crystals is represented Plate V. fig. 3. According to Haüy, the regular octahedron is the primitive form.

The structure is imperfectly laminar or fibrous, and diverging. Its specific gravity is about 3.4. It yields to the knife, but is harder than common calamine. It is soluble without effervescence in muriatic acid, and gelatinizes. Before the blow-pipe it is infusible; this property, with its greater specific gravity, distinguish it from zeolite. It contains — Oxide of Zinc 68.3, Silex 25, Water 4.4. Smithson.

Electric calamine occurs near Ticknall at Stanton Harold, on the edge of Derbyshire, and in Flintshire. Like cinnamon calamine, it accompanies the ores of lead.

Sp. 4. AUTOMALITE, *Spinelle Zincifere*, Haüy. — This mineral, which has been found imbedded in talc slate at Fahlun in Sweden, is classed by Haüy with spinel. Its colours are muddy greenish-blue; it occurs crystallized in small regular octahedrons or tetrahedrons; it is nearly opaque; has a glistening lustre varying from pearly to semi-metallic. Its specific gravity is from 4.26 to 4.69. Its hardness is very inferior to spinel. It contains — Oxide of Zinc 25, Alumine 42, Silex 4, Iron 5, Sulphur 17 — Loss 4. Vauquelin. See SPINEL.

GENUS XI. — BISMUTH.

Sp. 1. *Native Bismuth.*
2. *Sulphuretted Bismuth.*
Plumbo-Cupreous Bismuth.
Cupreous Bismuth.
3. *Bismuth Ochre.*

BISMUTH was unknown to the ancient nations in Europe. It is mentioned by the German Agricola in the year 1529; it was then well known in Germany as a peculiar metal, and considered as imperfectly-formed silver. Bismuth is found native, and combined with sulphur and with oxygen. Bismuth generally occurs in veins accompanied with ores of cobalt, arsenic, and silver, and is rather a scarce mineral. It is found more plentifully in Saxony and Bohemia than in other parts of Europe; it occurs, however, in small quantities in some of the mines of Cornwall, France, Norway, Sweden, and at Trumbull in Connecticut, in the United States.

Native bismuth is the ore from which the bismuth of commerce is obtained.

Sp. 1. NATIVE BISMUTH has all the properties of metallic bismuth. The colour is silver-white with a tinge of red or yellow, and generally tarnished externally; the lustre is metallic and splendent. Externally, the structure is laminar, with cleavages in three directions. It occurs massive, disseminated, and in plates, either plumose or dendritical. The crystals are regular octahedrons, which is the primitive form, or acute rhomboids with alternate angles of 120° and 60°. The specific gravity is about 9.02; it is soft and sectile; it may be flattened a little with the hammer, but is not malleable.

Native bismuth is extremely fusible, melting in the flame of a candle; it is volatilized by the continued action of the blow-pipe in white vapours, which have an arsenical odour. It is soluble with effervescence in nitric acid, and forms a white precipitate on the addition of water. This may serve as a distinctive character of bismuth. Native bismuth is sometimes so minutely disseminated in the matrix as to be imperceptible; but on the application of heat, the metal oozes out, and forms globules on the surface.

Sp. 2. SULPHURETTED BISMUTH, *Bismuth Sulfuré.* — The colour is light lead-grey, often tarnished externally; the lustre splendent or shining. It occurs amorphous, disseminated, and in acicular crystals. The structure is laminar with joints parallel to the planes and smaller diagonal, of a slightly rhomboidal prism. Sometimes it presents a radiated structure. The specific gravity is from 6.10 to 6.46. It is soft, and soils the fingers. Sulphuretted bismuth is somewhat sectile, but is easily frangible; it melts and is volatilized by the blow-pipe. The constituent parts are — Bismuth 60, Sulphur 40.

PLUMBO-CUPREOUS BISMUTH, NEEDLE-ORE. — The colour is steel-grey with a tinge of copper-red, and a shining metallic lustre; it occurs in six-sided acicular prisms. The specific gravity is 6.2. It is fusible into a steel-grey globule; by continuance of the heat it is partly volatilized, and a small globule of metallic lead remains with a red incrustation. This ore contains — Bismuth 43.2, Lead 24.3, Copper 12.1, Nickel 1.5, Tellurium 1.3, Sulphur 11.3. It occurs in the mines of Berezof in Cathareneburg in Siberia.

CUPREOUS BISMUTH ORE is extremely rare. The colour is lead-grey or steel-grey; the lustre shining and metallic; it is soft and sectile. It contains — Copper 34, Bismuth 47, Sulphur 60.

SP. 3. BISMUTH OCHRE, *Bismuth Oxydé.* — The colour is yellowish-white or grey; it is opaque; the structure is laminar, fine-grained, or earthy; it is soft, and frequently friable. It is reducible to the metallic state on charcoal. The specific gravity is from 4.30 to 4.70.

GENUS XII. — ANTIMONY.

SP. 1. *Native Antimony.*
Arsenical Antimony.
2. *Sulphuret, or Grey Antimony.*
SP. 3. *Red Antimony.*
4. *White Antimony.*
Antimonial Ochre.

Though the ancients were unacquainted with metallic antimony, they appear to have used some of its ores medicinally. The *Stibium* mentioned by Pliny, is supposed to be the oxide of antimony. This metal is found in small quantities native, but is commonly combined with sulphur, and sometimes also with oxygen. The ores of antimony most frequently occur in veins; sometimes the veins contain only ores of antimony and quartz; in other instances, the ores of antimony are accompanied by ores of gold, silver, lead, and iron. The antimony of commerce is obtained from the sulphuret. The easy fusibility of the ores of antimony, joined with the characters which will be described under each species, will serve to distinguish them from the ores of other metals.

Sp. 1. NATIVE ANTIMONY, *Antimoine Natif.* — This mineral possesses all the properties of the antimony of commerce. Its colour is tin-white, sometimes externally tarnished; the lustre splendent and metallic; the structure is distinctly laminar, parallel to the planes of the regular octahedron or rhomboidal dodecahedron; it yields to the knife, but is easily frangible. The specific gravity is 6.72. When heated by the blow-pipe it exhales a white vapour. If the melted globule cool slowly, it is covered with brilliant acicular crystals. It contains — Antimony 98, Silver 1, Iron 0.25. (Klaproth). Native antimony differs from native bismuth in colour, and it cannot be in any degree flattened by the hammer. It is much softer than arsenical pyrites; it does not exhale a sulphureous odour like the sulphuret of antimony, nor leave a globule of silver when melted and volatilized, like antimonial silver. Native antimony is found at Allemont near Grenoble, and at Salzberg in Sweden, and in the Hartz.

Arsenical Antimony. — This alloy has been found with native antimony at Allemont. It contains from 2 to near 16 per cent. of metallic arsenic, and yields a white vapour when heated with the blow-pipe or struck with a hammer. The laminæ are smaller and more brilliant than in native antimony.

Sp. 2. SULPHURET OF ANTIMONY, *Antimoine Sulfuré.* — The colour is lead-grey, the lustre metallic, but often tarnished externally and irridescent. It occurs massive, disseminated, and crystallized. Sulphuret of antimony is extremely soft, and is very easily reduced to a black powder that stains the fingers. Its specific gravity is from 4.10 to 4.50. It melts in the flame of a candle. When placed before the blow-pipe on charcoal, it becomes so fluid as to sink into the pores and disappear.

Massive Sulphuret of Antimony is generally composed of aggregated needles or small blades, which are diverging and sometimes intersecting. It has more rarely a promiscuously laminar or granular structure, more or less fine, passing into compact.

Crystallized Sulphuret of Antimony frequently occurs in long slender rhomboidal prisms, terminated by a four-sided pyramid, as represented Plate IV. fig. 40. The crystals are often acicular or capillary. The cleavage is parallel to the sides and axis of the prism. The primitive form is unknown. The acicular crystals often occur in groups, radiating from a centre.

Plumose Sulphuret of Antimony occurs in very minute filaments, forming a kind of down, on the surface of other minerals.

The constituent parts of this species are — Antimony 75, Sulphur 25. Sulphuret of antimony is found in some of the mines of Cornwall, near Padstow. It occurs in various counties of Europe; and it has recently been found in various parts of the United States.

SP. 3. RED ANTIMONY, *Antimoine Oxydé Sulfuré.*—The colour is cherry-red, but generally tarnished or irridescent externally. It has a structure like that of the common sulphuret, composed of diverging acicular or capillary crystals. It also occurs amorphous, and in thin plates; the lustre is shining. It is opaque and soft, forming a red powder. Before the blow-pipe it melts and evaporates, giving a sulphureous odour. The specific gravity is about 4. It contains—Antimony 67.50, Oxygen 10.50, Sulphur 19.70. This ore is found with sulphuret of antimony in Saxony, France, and Hungary.

SP. 4. WHITE ANTIMONY, *Antimoine Oxydé.* — The colour is white or yellowish-white, and the lustre pearly. It occurs crystallized and incrusting other minerals, and rarely massive. The crystals are rectangular tables, or acicular prisms collected in diverging groups. It is translucent and extremely soft. It melts and is volatilized before the blow-pipe. The constituent parts are — Oxide of Antimony 86, Oxide of Iron with Antimony 3, Silex 9. It occurs with other ores of antimony in various parts of Europe.

ANTIMONIAL OCHRE. — This ore is of a straw-yellow colour, passing into brown; it is soft, brittle, and earthy; it frequently occurs incrusting the sulphuret of antimony, and is probably formed from the decomposition of that mineral. It is volatilized by the blow-pipe.

GENUS XIII. — ARSENIC.

SP. 1. *Native Arsenic.*
2. *Arsenical Pyrites.*
3. *Sulphuret.*
Realgar.
Orpiment.
SP. 4. *Oxide of Arsenic.*
5. *Pharmacolite.*

The ores of arsenic very frequently accompany the ores of various metals either in veins or beds. Arsenic occurs native, and alloyed with other metals; it is also found combined with sulphur or with oxygen. Arsenic, in its combinations with oxygen, forms substances which have the properties of acids, and are deadly poisons. These acids combine with other metals, and form distinct species of ore, as the arseniates of lead, of copper, of iron; they are described with the ores of those metals. Arsenic acid also combines with lime, and forms a distinct species, but which is of rare occurrence.

Arsenic and its ores all yield the smell of garlic when heated; and though other ores may yield the same odour from an admixture with arsenic, yet the extreme volatility of the ores of this metal, distinguishes them from those of other metals. Metallic arsenic is so highly combustible that it explodes more vehemently than gunpowder, when triturated with the oxymuriate of potash and set fire to.

Sp. 1. NATIVE ARSENIC, *Arsenic Natif.* — The colour, when fresh, is pale lead-grey or tin-white, and the lustre metallic, and glistening or shining; but it soon becomes dark or nearly black and dull, by exposure to the air. It occurs amorphous, and in botryoidal or mamillated masses, and disseminated, and also cellular. The masses are composed of concentric laminæ. Sometimes the structure approaches to divergingly fibrous, or is granular. Native arsenic yields to the knife and acquires a polish by friction. It is reduced to powder by the stroke of a hammer. It burns with a blueish flame before the blow-pipe, and is entirely volatilized, except a minute portion of iron, gold, or silver, with which it is sometimes alloyed. The specific gravity is 5.67 to 5.72. Native arsenic occurs with the ores of silver, copper, and cobalt, in various parts of Europe.

Sp. 2. ARSENICAL PYRITES, *Mispickel*, *Fer Arsenical.* — The colour is tin-white; the lustre metallic, and splendent or shining, but sometimes tarnished either blueish, yellowish, or green. It occurs massive or crystallized in oblique rhomboidal prisms, which have sometimes dihedral summits, and are truncated on the edges or angles. The primitive form is a right rhomboidal prism, with alternate angles of 111° 18′ and 68° 42′. (Haüy.) The fracture is granular. The specific gravity is 6.50. It gives fire with steel; when rubbed it emits an arsenical odour. Before the blow-pipe it gives out white arsenical vapours, leaving the oxide of iron, which attracts the magnet. Arsenical pyrites contains, according to Berzelius — Arsenic 54.35, Iron 45.46: — or, Arsenic 48.1, Iron 36.5, Sulphur 15.4. (Thompson.) This ore is very abundant in the copper and tin veins in Cornwall.

White oxide of arsenic, and artificial orpiment, are prepared from arsenical pyrites.

SP. 3. SULPHURET OF ARSENIC, *Arsenic Sulfuré*, is composed of metallic arsenic combined with sulphur. It is soft and easily frangible. It burns and emits the odour of sulphur and of arsenic. This species is divided into two varieties, the red or realgar, and the yellow or orpiment.

REALGAR.—The colour is bright aurora-red passing into scarlet or orange-red; it is translucent or semi-transparent. The powder and streak are orange coloured; it occurs massive, disseminated, crystallized, and acicular. Realgar is soft, yielding to the nail; the fracture is conchoidal, and the lustre inclines to vitreous; it acquires, by rubbing, resinous electricity. Its specific gravity is 3.30.

According to Haüy, the primitive form of the crystals is an octahedron with scalene triangular faces. The secondary forms are generally prismatic, with pyramidal summits (Plate IV. fig. 32.)

Realgar is commonly found in the fissures of lava near the craters of volcanoes. It is found also in veins in primitive mountains, both compact and efflorescent. It contains — Arsenic 69, Sulphur 31. (Klaproth.)

ORPIMENT is of a lemon-yellow colour, with a brilliant lustre, inclining to semi-metallic or adamantine. Its structure is laminar; the laminæ are translucent, soft, and flexible, and easily separated; its other properties agree nearly with those of realgar; it contains—Arsenic 62, Sulphur 38. It occurs in veins intermixed with realgar. The orpiment of commerce comes from the Levant. (Brongniart.)

The Red Sulphuret of Arsenic is distinguished from red silver-ore, cinnabar, or red-lead, by its inferior specific gravity, the colour of its powder, and its extreme volatility. The yellow is distinguished from these ores by its colour.

Sp. 4. OXIDE of ARSENIC occurs in some European mines crystallized in quadrangular prisms, also acicular and pulverulent. It is white and entirely volatile, exhaling the odour of garlic. The crystals are transparent. Oxide of arsenic is soluble in water. (Jameson.) This serves to distinguish it from the following species.

Sp. 5. PHARMACOLITE, *Chaux Arseniaté*, Haüy.—This mineral has hitherto only been discovered in a few mines in Germany; it occurs in veins with ores of cobalt. The colours are white, sometimes reddish or yellowish-white; it varies from semi-transparent to opaque; the external lustre is glimmering and silky. It occurs incrusting other ores; also reniform, botryoidal, and in capillary crystals divergingly aggregated. The structure is fibrous. Pharmacolite is soft or nearly friable, yielding to the nail. Its specific gravity is about 2.55. Before the blow-pipe it is almost entirely volatilized. It is not soluble in water like the oxide of cobalt. Its constituent parts are — Arsenic Acid 50.54, Lime 25, Water 24.46. Klaproth.

Genus XIV. — COBALT.

Sp. 1. *Arsenical Cobalt.*
White Cobalt.
Grey Cobalt.
2. *Sulphuret of Cobalt.*
3. *Earthy Cobalt.*
Sp. 4. *Cobalt Bloom, or Arseniate of Cobalt.*
5. *Sulphate of Cobalt.*

Metallic cobalt was first obtained from its ores in the year 1733, by the Swedish chemist Brandt. The ores of cobalt were employed to give a blue colour to glass at an earlier period. Cobalt has never been discovered native. It occurs combined with arsenic, with iron, with sulphur, with oxygen, also with the arsenic and sulphuric acids. All the ores of cobalt may be easily recognized by the property of giving a bright blue colour to glass or borax. The ores of cobalt, except the oxide, generally occur in mountains of granite, gneiss, or mica-slate, either in veins, or imbedded masses, or disseminated. The principal mines of cobalt are in Saxony, Bohemia, and Sweden.

Sp. 1. ARSENICAL COBALT, *Cobalt Arsenical*, and *Cobalt Gris*, Haüy. — Some mineralogists divide arsenical cobalt into three species, from the colour, as white cobalt, tin-white cobalt, and grey cobalt. These ores appear, however, to contain nearly the same constituent parts, and to have the same crystalline forms.

White Cobalt Ore has a silver-white or yellowish-white colour, sometimes tinged with red, or tarnished with purple; the external lustre is splendent and metallic. It occurs massive, disseminated, and crystallized in cubes, and the other forms of common iron pyrites, particularly in cubo-octahedrons (Plate V. fig. 1.), and in striated cubes (Plate V. fig. 6.); another variety is represented fig. 2. The structure is laminar, parallel to the faces of the cube; the cross-fracture is small conchoidal. The specific gravity is about 6.9. (Lowry.) It yields to the knife. Before the blow-pipe it turns black at first, but does not give out arsenical vapours until it approaches to a red heat; it afterwards melts into a metallic globule; it colours borax a deep blue. This ore is an alloy of metallic cobalt and arsenic, containing — Cobalt 44, Arsenic 55.5, Sulphur 0.5. (Klaproth.) Some analyses give less cobalt and more arsenic.

TIN-WHITE COBALT, *Cobalt Arsenical*, differs little in appearance from the preceding variety; it occurs in similar crystals. It is also found stalactitical, botryoidal, dendritical, and amorphous. It has not the laminar structure of white cobalt; the fracture is fine-grained, it is also harder than white cobalt. When exposed to the blow-pipe, it immediately emits white arsenical vapours. It can only be partially melted without the addition of borax, to which it gives a deep blue colour. The specific gravity varies from 6.2 to 7.3.

GREY COBALT, *Var de Cobalt Arsenical*, *Dull-grey Cobalt*, Kirwan. — The colour is steel-grey or inclining to tin-white, but often tarnished externally blueish or black. The lustre is metallic, and glistening or shining. It occurs amorphous, botryoidal, and stalactitical. The fracture is even, conchoidal, or granular; it yields to the knife, and is easily frangible. The specific gravity is about 5.5. Klaproth found in this ore near twenty parts of cobalt, intermixed with arsenic and iron.

Grey-cobalt is found with tin-white cobalt in the copper veins of Herland and Dolcooth mines, in Cornwall. This ore ought probably to be regarded as a variety of white cobalt, rendered impure by an admixture with iron.

Arsenical cobalt and its varieties are the only ores that are explored for cobalt.

SP. 2. SULPHURET OF COBALT, *Cobalt Sulfuré.*—This ore is of little importance; it has only been found near Riddarhyttan in Sweden. The colour is pale steel-grey, tarnished externally copper-red; the lustre is shining and metallic. It occurs amorphous and disseminated; its fracture is uneven, passing into conchoidal. Before the blow-pipe, it emits sulphureous vapours. It contains — Cobalt 43.2, Sulphur 38.5, Copper 14.4, Iron 3.53.

SP. 3. EARTHY COBALT, *Cobalt Oxydé.*— This ore occurs blueish-black or dingy-yellow, and brown; it is dull and earthy. Earthy cobalt is found incrusting other minerals, also massive, mamillated, and botryoidal. It is soft, passing into friable. All the varieties tinge borax blue; this distinguishes earthy cobalt from the earthy oxide of manganese. Black earthy cobalt is found at Alderley Edge, in Cheshire, in a hill of stratified sandstone. The following account I shall extract from a short description of this place, which I published in the Monthly Magazine for Feb. 1811. " The ore occurs in the form of grains of a blueish-black colour: they are disseminated in red sand-stone, and bear a close resemblance to grains of gunpowder; or they occur in thin seams between the strata of sand-stone, which has a slaty structure. It lies from eight to ten yards below the surface, and is got out in thin layers, which are afterwards separated as much as possible from the stone. The ores of lead and copper in this hill are mixed together in a state of confusion, but the cobalt-ore is stratified, and though near, is not intermixed with other ores. It lies near the surface, and is evidently of later formation than the other parts of the hill, as the red sand-stone in which it is found, lies upon or intersects the white sand-stone; the latter is the repository of the other ores."

Sp. 4. COBALT-BLOOM, ARSENIATE of COBALT, *Cobalt Arsenié.*—The colour of this ore is peculiar, being violet-red, or peach-blossom-red, passing sometimes into whitish-red: like the other ores of cobalt, it tinges borax blue; these characters conjointly are sufficiently distinctive. Cobalt-bloom occurs earthy, and incrusting other ores of cobalt, and serves to indicate their presence; it is also found in divergent acicular crystals, which are more or less shining and translucent, and in small botryoidal concretions, which are dull and opaque. The crystallized cobalt-bloom contains — Cobalt 38, Arsenic Acid 38, Water 23. (Bucholz.) Before the blow-pipe, the arsenic acid is driven off, and a grey oxide remains. Cobalt-bloom is found in almost all veins that contain white and grey cobalt ores.

Sp. 5. SULPHATE of COBALT, is of a pale rose-red colour. It is soluble in water, and will be enumerated among the salts, Book V.

GENUS XV. — TELLURIUM.

SP. 1. *Native Tellurium.*	*Yellow Tellurium.*
Graphic Tellurium.	*Black Tellurium.*

TELLURIUM was discovered as a new metallic substance in 1782, but its properties were first ascertained by Klaproth in the year 1796. It is highly combustible and volatile, and has not hitherto been applied to any useful purpose in the arts. The ores of this mineral have been found only at Facebay, Offenbayna, and Nagyag in Translyvania.

Tellurium is always more or less mixed or alloyed with gold, or with silver, iron, lead, or copper; what is called native tellurium, being properly an alloy. Tellurium, when burned by the blowpipe, emits a peculiar odour, resembling that of horse-radish. This metal bears a near resemblance to antimony, but it is softer, and has less specific gravity; it forms a colourless solution in nitric acid, and is precipitated from it in a metallic state by antimony, which proves clearly that they are distinct species of metals. Klaproth.

SP. 1. NATIVE TELLURIUM. — The colour is between tin-white and lead-grey, but sometimes reddish or yellow externally. The lustre is shining and metallic; it occurs in minute crystals or crystalline grains, either aggregated in masses or disseminated; the structure is laminar or radiated: it yields to the knife, is brittle, and easily frangible. The specific gravity is from 5.73 to 6.11. Tellurium melts before it becomes red, and emits a dense white vapour; by the continuance of the heat it burns with a greenish-coloured flame, and is volatilized, emitting the pungent odour of horse-radish. When melted and cooled slowly, the surface is covered with radiated crystals.

Native tellurium contains — Tellurium 92.55, Iron 7.20, Gold 0.25. It occurs at Facebay in veins that traverse porphyry, with iron pyrites, quartz, and lithomarge. (Klaproth's Essays, vol. ii. p. 2.)

GRAPHIC-TELLURIUM, *Tellure Natif Auro-Argentifere.* — The colour is tin-white, with a tinge of brass-yellow; the lustre is externally brilliant and metallic. It occurs in veins at Offenbayna in thin plates upon grey-quartz, or in the fissures of grey argillaceous porphyry; it also occurs in crystallized small low quadrangular prisms, which are arranged in rows forming a representation of Persepolitan characters. The specific gravity is 5.72; it is soft and brittle. It contains — Tellurium 60, Gold 30, Silver 10. Before the blow-pipe it burns with a green flame, and is volatilized.

YELLOW TELLURIUM, *Tellure Aurifere et Plumbifere.* — This ore occurs massive or coarsely disseminated with quartz and brown spar, in irregular veins at Nagyag. It is sometimes crystallized in small flat four-sided prisms. The colour is silver-white passing into brass-yellow; the lustre is shining and metallic; its structure laminar; it is soft and rather sectile. Its specific gravity is 10.67. Muller. It contains — Tellurium 44.75, Gold 26.75, Lead 19.50, Silver 8.50, Sulphur 0.50.

Black Tellurium. — The colour is deep lead-grey passing into iron-black; the lustre shining and metallic; the structure is curvedly laminar, with one distinct cleavage. It occurs in thin plates, or crystallized, and sometimes massive. The crystals are flat tables with four, six, or eight sides, or truncated octahedrons. This ore is soft and sectile, and the separate laminæ are flexible; it stains the fingers. Before the blow-pipe it melts, and emits a dense vapour; a blackish globule remains, which on being melted with borax affords a globule of alloy of gold and silver. This ore contains — Tellurium 32, Lead 54, Gold 9, Sulphur 3, Copper 1.3, Silver 0.5.

The ores of tellurium are explored as gold ores, on account of the gold they contain. For a particular account of the mines, see Dr. Clarke's Travels, vol. iv.

Genus XVI. — MANGANESE.

Sp. 1. *Grey Manganese Ore, or Oxide of Manganese.*
Wad.
2. *Sulphuret of Manganese.*
Sp. 3. *Carbonate of Manganese.*
4. *Phosphate of Manganese.*

Manganese has only been known as a metal since the year 1774, though its ores are common and abundant. Manganese when obtained in a pure metallic state is of a greyish-white colour, with a shining metallic lustre, and a granular structure; the hardness is equal to iron, but it is destitute of malleability. It cannot be preserved in a metallic state when exposed to the atmosphere. Manganese is generally found combined with oxygen; it occurs in beds, in slate and red sand-stone. Manganese is more rarely found combined with sulphur or with carbonic or phosphoric acids. The ores of manganese may generally be recognized by the property of communicating a purple or violet colour to borax, or to a mixture of borax and nitre. In muriatic acid, they emit the odour of oxymuriatic acid.

Sp. 1. GREY MANGANESE, or OXIDE of MANGANESE, *Manganese Oxydé.* — The colour is steel-grey passing into iron-black; the lustre varies from splendent and metallic, to glimmering or dull. This ore occurs in a great variety of forms, either regularly crystallized or acicular, also massive, dendritical, and pulverulent. The massive varieties have either a granular, a laminar, or a fibrous structure, or are compact, and sometimes earthy and dull.

Grey manganese is soft and brittle, except the compact variety. It soils strongly when rubbed; the powder is greyish-black, and is dull. The specific gravity is below 5. It is infusible before the blow-pipe, and tinges borax purple. The crystallized variety yielded (Klaproth) — Oxide of Manganese 90.5, Oxygen 2.25, Water 7. The compact — Oxide of Manganese 60, Silex 25, Water 13. Klaproth.

Crystallized Manganese. — The primitive form is a rhomboidal prism, with alternate angles of 100° and 80°. (Haüy.) The prisms are often truncated on the edges, and terminated by dihedral or tetrahedral planes (see Plate IV. fig. 39.) The structure is laminar, with a cleavage in the direction of the smaller diagonal of the base. It occurs also in diverging acicular prisms, and nearly resembles the sulphuret of antimony, but may be distinguished by its infusibility.

MASSIVE GREY MANGANESE has sometimes a fibrous or a granular structure, and is sometimes earthy; the latter variety is dull. It also occurs compact, in stalactitical or botryoidal concretions.

Grey manganese is the ore employed by bleachers for obtaining oxymuriatic acid, and by glass-makers to improve the colour of the glass, and by chemists to obtain oxygen gas. This ore occurs at Upton Pyne and Dodscomb Leigh, in Devonshire. In the latter place, it forms beds in red sand-stone, varying from two to four feet in width, and dipping at an angle of about 40°. The beds are worked from the top, and are richer near the surface than below. The stratum on which the manganese rests, I found to be a hard quartzose rock, coloured red, and passing into jasper. The intermixture of manganese with red quartz has given rise to the variety called by Haüy *manganese oxydé silicifere*.

Grey oxide of manganese has been found in considerable quantities crystallized at the village of Hartshill, near Atherstone, in Warwickshire. I have observed several beds of this ore near Cromack Water, in Cumberland.

WAD is composed of an intermixture of the oxides of iron and manganese, and has generally a dark-brown colour; it occurs amorphous, botryoidal, and pulverulent; it has an earthy texture, and is dull. It occurs in Derbyshire and Devonshire, and in other situations, accompanying the ores of iron or of manganese.

SP. 2. SULPHURET OF MANGANESE.—This ore is much more rare than the preceding species; it has been found in some parts of Cornwall, and with tellurium ore in Transylvania. The colour when fresh is steel-grey; the lustre shining and metallic, but soon becomes tarnished black. It occurs massive with an imperfectly laminar structure; it is opaque, yields easily to the knife, and is rather sectile. It tinges nitrous borax purple. The specific gravity is 3.95. This ore contains—Oxide of Manganese 82, Sulphur 11, Carbonic Acid 3. Klaproth.

SP. 3. CARBONATE OF MANGANESE, *Manganese Oxydé Carbonaté*, Haüy, *Manganese Lithoide*, Brongniart.—Its colours are reddish-white, or rose-red, also yellowish-brown; it is dull and slightly translucent; it is sufficiently hard to scratch glass, but is brittle and easily frangible. It has been found massive and disseminated at Kapnick in Transylvania. It contains — Oxide of Manganese 48, Iron 2.1, Silex 9, Carbonic Acid 49.2. Lampadius.

SP. 4. PHOSPHATE OF MANGANESE, *Manganese Phosphaté ferrifere.*—This ore has been found in granite at Limoges in France. The colour is brownish-black or brown; it is translucent; the lustre resinous and shining or glistening. It has an indistinct laminar structure, with cleavages parallel to the planes of a rectangular parallelopiped. (Haüy.) The specific gravity is from 3.40 to 3.77. Before the blow-pipe it melts into a black enamel. It contains — Oxide of Manganese 42, Oxide of Iron 31, Phosphoric Acid 27. Vauquelin.

The only ore of manganese that is worked for this mineral is the oxide.

GENUS XVII. — MOLYBDENA.

Sp. 1. *Sulphuret of Molybdena.*
Molybdena Ochre.

MOLYBDENA can only be reduced to the metallic state with great difficulty. It occurs combined with sulphur, forming a substance nearly resembling plumbago, with which it was long confounded; it also occurs combined with oxygen, forming a peculiar acid, the molybdic; this acid unites with lead, forming the molybdate of lead. (See LEAD.) Molybdena was first reduced to a metallic state by Heilm in the year 1782. It has not been applied to any useful purpose in the arts.

SP. 1. SULPHURET OF MOLYBDENA. — The colour is bright lead-grey; the lustre shining and metallic; it occurs amorphous, disseminated, laminar, and crystallized, in short hexahedral prisms, sometimes terminated by low six-sided pyramids; the structure is laminar, with a single cleavage perpendicular to the axis of the prism. According to Haüy, the primitive form is a right four-sided prism with alternate angles of 120° and 60°. Sulphuret of molybdena marks paper slightly: when rubbed on porcelain, it leaves an olive-coloured stain: it feels unctuous to the touch, yields to the knife, and is flexible but not elastic. The specific gravity varies from 4.5 to 4.7. Before the blow-pipe it gives out a sulphureous odour, and at a great heat, burns with a light blue flame; it melts with effervescence when carbonate of soda is added. According to Bucholz, it contains — Sulphur 40, Molybdena 60. — This ore is found in veins in various parts of Cornwall, and disseminated in white granite at Calbeck-fell in Cumberland; it occurs in Scotland and various parts of Europe.

Molybdena Ochre occurs disseminated, and in friable incrustations on the sulphuret of molybdena; its colours are sulphur-yellow, light yellow, or green.

Genus XVIII. — URANIUM.

Sp. 1. *Black Oxide of Uranium, or Pitch-blende.*	Sp. 2. *Uranite.* *Uran Ochre.*

Uranium was first obtained in a metallic state from its ore by Klaproth in 1789. It is infusible in a common furnace; the colour is iron-grey, the lustre shining and metallic; it yields to the file. The quantity of metal hitherto procured, is too small to admit of experiments respecting many of its properties. Uranium is found combined with oxygen in some of the mines of Cornwall, and in Bohemia and Saxony.

Sp. 1. BLACK OXIDE of URANIUM, PITCH-BLENDE, *Urane Oxydulé.* — The colour is black, inclining to greyish-black or brown. The lustre, internally, is resinous and glistening or shining. It is opaque or slightly translucent on the edges. This ore occurs amorphous and in globular or reniform concretions.

The structure is sometimes curvedly lamellar. The fracture is imperfectly conchoidal, passing into uneven. It yields to the knife and is brittle. The specific gravity is from 6.53 to 7.50. Before the blow-pipe it is infusible, but with borax it yields a grey slagg, and with phosphate of soda, a clear green globule. This ore dissolves in nitric acid, forming a pale orange solution. It contains — Oxide of Uranium 86.5, Black Oxide of Iron 2.5, Sulphuret of Lead 6, Silex 5. Klaproth.

Pitch-blende is found disseminated in veins that contain tin-stone at Tol-Carn mine in Cornwall.

Sp. 2. URANITE, URAN MICA, *Urane Oxydé*.— The colours are grass-green, emerald-green, and greenish-yellow; the lustre shining and pearly; it occurs crystallized in right rectangular prisms with square bases, in which the proportion of the height is to the length of the base as 11 to 17; this is the primitive form. When the height of the prism is diminished, it forms a quadrangular table. Sometimes the prisms or tables are truncated on the angles or edges. The structure is laminar with three rectangular cleavages parallel to the sides of the primitive crystal, but the cleavages parallel to the base are the most distinct. Uranite yields easily to the knife. Its specific gravity is 2.19. Before the blow-pipe on charcoal it decrepitates, and acquires a brass-yellow colour; with borax it yields a green glass. It dissolves in nitric acid, forming a greenish-yellow solution. The constituent parts are — Oxide of Uranium 74.4, Oxide of Copper 8.2, Arseniate? Water 15.4, Loss 2. (Gregor). The yellow uranite, according to Berzelius, is a uranite of lime, containing much water of crystallization. Uranite is found in veins in various parts of Cornwall, and in Saxony, France, and near Baltimore in Maryland.

Uran-Ochre occurs yellow or yellowish-brown, and is soft or friable; it is generally found incrusting the black oxide of uranium. It is opaque and dull. According to Klaproth, it is an oxide of uranium. The brownish-coloured varieties contain iron.

Genus XIX. — TUNGSTEN.

Sp. 1. *Wolfram.*	Sp. 2. *Tungstate of Lime.*

Tungsten has hitherto been obtained from its ores only in small metallic globules. The colour resembles that of steel; it is extremely hard, and melts with great difficulty. Its specific gravity is said to be 17.22. Tungsten is found in the state of an oxide, forming a peculiar acid, which is combined with iron and manganese, or with lime. The former combination, called wolfram, is very abundant in some of the mines of Cornwall. The ores of tungsten have not been applied to any useful purpose.

Sp. 1. **WOLFRAM,** *Scheelin Ferruginé.* — The colour is brownish-black, or dark-brown; the lustre metallic, and shining or glistening; the colour of the powder is reddish-brown. It occurs in amorphous masses, also disseminated and crystallized. The primitive form is a low rectangular prism (Plate IV. fig. 33.)

One of the secondary forms, *epointé*, is represented fig. 34. The structure of wolfram is perfectly laminar in one direction, and imperfectly laminar in two directions, at right angles with the above. It yields to the knife, and is brittle, and easily frangible. The specific gravity is from 7 to 7.30. It decrepitates before the blow-pipe, and melts into a black slagg, which is not magnetic. It contains — Tungstic Acid 64, Oxide of Manganese 22, Oxide of Iron 13.5. Klaproth. Wolfram is found in the tin veins of Cornwall, and in Saxony and France. The reddish-brown colour of the powder or streak and inferior hardness, distinguish it from tin-stone.

Sp. 2. TUNGSTATE of LIME, or TUNGSTEN, *Scheelin Calcaire.* — The prevailing colours are greyish or yellowish-white; it is more or less translucent. It occurs massive and crystallized in octahedrons. The primitive form is an acute octahedron, in which the planes at the common base form angles of 130° 20′; the secondary forms are shorter octahedrons, in which the planes form angles of 107° 26′, and four-sided tables. The structure is laminar, parallel to the planes of the primitive octahedrons, and to the common base of the two pyramids. The lustre of the crystals is shining or splendent, and adamantine. Internally the lustre is resinous and shining. Tungstate of lime yields without difficulty to the knife, and is easily frangible. Its specific gravity varies from 5.80 to 6.00. Before the blow-pipe it becomes opaque, but does not melt; with borax it forms a glass, more or less transparent, according to the proportions; it becomes yellow in nitric acid, but does not dissolve. It contains — Acid of Tungsten 77.75, Lime 17.60, Silex 3. Klaproth. This ore occurs with wolfram and tin-ore in Cornwall.

From carbonate of lead, it may be distinguished by its insolubility in nitric acid. From sulphate or carbonate of barytes, by its greater specific gravity, and its yellow colour when dissolved in nitric acid.

GENUS XX. TITANIUM.

Sp. 1. *Titanite, or Rutile.*
Anatase?
2. *Ferruginous Oxide of Titanium.*
Menachanite.
Isorine.
Nigrine.
Sp. 3. *Sphene.*

This metal has hitherto only been found in the state of an oxide, either pure or combined with other minerals. The oxide of titanium combined with oxide of iron, was first discovered by Mr. Gregor, in the form of black grains, in the sand of the valley of Menachan in Cornwall. Another ore, containing pure oxide of titanium, was analysed by Klaproth in 1795; and in 1796, titanium was obtained in a metallic state. It has a dark-red colour, a bright metallic lustre, and is brittle; but thin laminæ of this metal are elastic. Titanium is found as a component part of most dark-coloured lavas, and in various basaltic rocks; and it has been recently discovered by Berzelius in the iron-ore of Elba. Since its first discovery, titanium has been found in the form of black grains in the sands of various rivers, in different parts of the world. Some mineralogists have classed the oxides of titanium found in different rivers as distinct species, though they present a greater external resemblance, and agree more nearly in their constituent parts, than the varieties of any other species of ore.

Sp. 1. TITANITE, RUTILE, *Titane Oxydé.*—The colours are blood-red, orange-red, and dark brownish-red; the lustre externally shining or glistening; internally the faces of the laminæ are splendent and adamantine, approaching to semi-metallic; the cross-fracture, which is conchoidal or uneven, has a shining or glistening lustre. Titanite varies from translucent to opaque; it occurs crystallized, disseminated, and amorphous. The structure is laminar, with a double rectangular cleavage, parallel to the lateral planes of a right prism, with square bases, which is the primitive form. According to Haüy, the length of the base is to the height of the prism as 11 to 17. The secondary prisms have sometimes six sides terminated by low six-sided planes, which are occasionally convex. The prisms are striated longitudinally, and sometimes bent or *geniculated*, as represented Plate IV. fig. 35. The hardness of titanite is sufficient to scratch window-glass; its specific gravity is from 4.18 to 4.24. It is brittle and easily frangible. Before the blow-pipe it is infusible, but it forms a transparent yellowish-red glass with borax. Titanite occurs also in capillary crystals either single, divergent, or crossing; these crystals are frequently imbedded in quartz, and bear some resemblance to hair; hence some pieces of rock-crystal which contain them have been called *Theti's hair-stones.* Titanite occurs more rarely in masses, with a fibrous or granular structure.

According to Klaproth, titanite is a pure oxide of titanium. Vauquelin found in one variety from Westmannland, a small portion of oxide of chrome, *Titane Oxydé Chromifere.*

Capillary Titanite is found in the rock-crystals of Snowdon, and in other parts of Caernarvonshire; and in the smoke-quartz of Cairngorm, and other of the Grampian mountains in, Scotland. Titanite occurs in primitive rocks in various counties of Europe.

ANATASE, or OCTAHEDRITE.—This mineral occurs in small crystals, and appears, from the analysis of Vauquelin, to be, like titanite, a pure oxide of titanium; but it differs from that mineral in the crystalline forms, which are acute octahedrons, sometimes truncated on the summits or the edges of the common base of the two pyramids, which form the octahedrons. One variety is represented Plate IV. fig. 38. in which the summits are replaced by four small planes. The crystals are indigo-blue or reddish-brown; they are semi-transparent, and when held between the eye and the light, the colour is greenish-yellow. The lustre is splendent and adamantine. The structure of anatase is laminar; it scratches glass. The specific gravity is near 4. Before the blow-pipe it is infusible, but yields a reddish-yellow glass with borax, which changes to white or blue by varying the degree of heat.

Anatase is found in veins with felspar and ascinite at Vaujani in Dauphiny, and in lime-stone in Norway.

Sp. 2. FERRUGINOUS OXIDE of TITANIUM, *Titane Oxydé Ferrifère.* — Oxide of titanium combines with iron in various proportions, and probably forms a constituent part of specular iron-ore, and of all iron-sand. Ferruginous oxide of titanium occurs in the sands of rivers, either in rolled pieces or in angular or rounded grains, which have an iron-black or brownish-black colour, a glistening semi-metallic lustre, and are opaque. Some varieties are affected by the magnet. The specific gravity varies from 4.27 to 4.50. It yields with difficulty to the knife.

Menachanite. — This variety was first found in the valley of Menaccan in Cornwall; it occurs in grains which have nearly the appearance of grains of gunpowder; they have a laminar structure, and are brittle and easily frangible; they are feebly attracted by the magnet. Menachanite is infusible by the blow-pipe; but with borax forms a greenish-glass inclining to brown. This ore contains — Oxide of Titanium 45.25, Oxide of Iron 51, Oxide of Manganese 0.25, Silex 3.50. Klaproth. From New Holland — Oxide of Titanium 40, Oxide of Iron 49, Silex 11. Chenevix.

Iserine, so called from the river Iser, differs from the former variety, in being fusible into a blackish-brown coloured glass. Iserine from the river Don, Aberdeenshire, contained — Oxide of Titanium 48, Oxide of Iron 48, Oxide of Uranium 4. Thompson.

Nigrine is not attracted by the magnet, and yields a yellowish-red glass, with borax. It contains — Oxide of Titanium from 53 to 84, Oxide of Iron from 47 to 14. It is found in the Uralian mountains, and in the Island of Ceylon.

SP. 3. SPHENE, *Titane Siliceo Calcaire.* — The colours are reddish or blackish-brown, sometimes inclining to grey, green, or yellow; the lustre shining or glistening, and vitreous or resinous; it is more or less translucent. Sphene occurs in small amorphous masses, and in grains, and crystals which are generally imbedded in sienite or granite. The crystals vary in size from large to small. One of the crystals, called by Haüy *dioctahedre*, is represented Plate IV. fig. 36.; and another crystal, a rhomboidal prism, terminated by dihedral summits, is represented Plate IV. fig. 37. According to Haüy, the primitive form is an octahedron with a rhomboidal base, the angles of which are 103° 20′ and 76° 14′, and the angle formed by the incidence of the planes at the common base 131° 16′. Sphene scratches glass; its specific gravity is from 3.48 to 3.50. It is fusible with difficulty in a dark-brown slagg; with borax it forms a yellowish-green glass. It contains — Oxide of Titanium 33, Silex 35, Lime 33. Klaproth. Sphene has been found in the granite of Aberdeen, the sienite of Galloway, and Loch Ness, and various parts of Scotland; it occurs in different parts of Europe, and in the United States. In the collection at the British Museum, there is an interesting series of the ores of titanium, including the flat octahedral crystals of sphene from Norway; and the gold-coloured rutile from Mont Blanc.

Genus XXI. — CERIUM.

Sp. 1. *Cerite.* *Yttro-Cerite.*	Sp. 2. *Allanite.* 3. *Fluate of Cerium.*

The ores of cerium have only been found in the northern part of the globe, in Sweden and Greenland. Metallic cerium has not yet been obtained from them, except in globules, too minute to admit of an examination of the properties. Cerium forms two oxides, the one white, the other red or brown.

Several new combinations of the oxides of cerium have been very recently discovered in Sweden, and examined by Berzelius, but we have at present only an imperfect account of them, and the specimens sent to the British Museum are too small to admit of a mineralogical description. The ores of cerium appear to be of little importance, except that some of them contain a minute portion of new earth, called *thorina.*

Sp. 1. CERITE, *Cerium Oxydé Silicifere.* — The colour is crimson passing to flesh-red and reddish-brown; the powder is greyish-white; the lustre glimmering and resinous. Cerite occurs massive and disseminated; the fracture is splintery; it scratches glass, and is brittle. The specific gravity is from 4.61 to 4.80. Before the blow-pipe it is infusible; but changes its colour and becomes grey or yellow by continued heat. It contains

— Oxide of Cerium 67, Silex 17, Oxide of Iron 2, Water and Carbonic Acid 12. Vauquelin.

Cerite is found in a bed of copper pyrites with other minerals, near Riddarhyttan in Westmannland, Sweden.

YTTRO-CERITE. — This ore has been recently found at Finbo in Sweden; its colours are various, passing from violet-red to greyish-white; it is opaque, and the lustre is glistening. Yttro-cerite occurs massive and incrusting; the structure is laminar; it yields to the knife, and is infusible before the blowpipe, but it melts on the addition of gypsum. The specific gravity is stated to be 3.44. According to Berzelius, it contains — Fluate of Cerium 20.22, Fluate of Yttria 10.60, Fluate of Lime 68.18.

SP. 2. ALLANITE, *Cerium Oxydé Silicifere Noire.* — The colour is brownish-black, the powder greenish-grey; it is dull and opaque; it is easily frangible, and the internal lustre is shining, and between resinous and metallic; it scratches glass. The specific gravity is from 3.5 to 4. This mineral was brought from West Greenland by Professor Gieseké, who discovered it imbedded in granite, both amorphous, and crystallized in four-sided and six-sided prisms. It contains — Oxide of Cerium 33.9, Oxide of Iron 25.4, Silex 35.4, Lime 9.2, Alumine 4.1, Moisture 4. Thompson. Before the blowpipe it melts imperfectly into a black scoria.

SP. 3. FLUATE OF CERIUM. — According to the analyses of Berzelius, cerium combines with three different proportions of fluoric acid. The sub-fluate contains the peroxide and protoxide of cerium, combined with fluoric acid. The colour is yellow. Fluate of cerium, or *Deuto-Fluate*, has been found at Finbo and Brodbo in very small quantities; the colour is red. Double fluate of cerium is of a pale red colour, and soft; it occurs at Finbo, with gadolinite.

Orthite and Pyrorthite, two minerals discovered with cerite and gadolinite at Fahlun, have been referred to under Gadolinite.

GENUS XXII.—TANTALUM.

Sp. 1. *Tantalite.* | Sp. 2. *Yttro-Tantalite.*

TANTALUM has not been reduced to a perfectly metallic state, its properties as a metal are therefore unknown; it is extremely rare, and is remarkable for its combination with a peculiar earth, called *Yttria*, from *Ytterby* in Sweden, where it was first discovered. Tantalum is combined with oxygen, and united with iron and manganese, and has been recently found combined with the above metals, and with tin, at Brodbo in Sweden. Tantalum was first discovered in an ore brought from the United States, but its locality there is at present unknown.

Sp. 1. TANTALITE, or COLUMBITE, *Tantale Oxydé Ferro-manganesifere.*—The colour of this ore is blueish-black or iron-black. The internal lustre is glistening and between metallic and resinous. It occurs disseminated in granite in Finland, in angular pieces or imperfect crystals, varying from the size of a pea to that of an hazel-nut. The crystals are imperfect prisms or octahedrons, with smooth or striated shining surfaces. The fracture is granular, sometimes passing into conchoidal; some specimens present indications of a laminar structure. Columbite scratches glass, is brittle and breaks with difficulty. The specific gravity is from 7.3 to 7.9. Before the blow-pipe it is infusible. The constituent parts are — Oxide of Tantalum 83, Oxide of Iron 12, Oxide of Manganese 8. Vauquelin. Or— Oxide of Tantalum 85, Oxide of Iron 10, Oxide of Manganese 4. Woollaston.

Sp. 2. YTTRO-TANTALITE, *Tantale Oxydé Yttrifère.* — This ore contains tantalum combined with the earth yttria. Its colour is iron-black; when powdered, grey: the lustre is glistening and resinous, or inclining to metallic. It has hitherto only been found in red felspar at Ytterby, near Roslagen in Sweden, where it occurs in small angular pieces, and in oblique four-sided prisms or six-sided prisms. It scratches glass and is brittle; the fracture is granular or compact. The specific gravity is 5.13. According to Vauquelin, it contains—Oxide of Tantalum 45, Oxide of Iron and Yttria 55.

A variety of tantalite, containing—Oxide of Tin 8.02, Tungstic Acid 5.78, Oxide of Iron 10.64, Oxide of Manganese 10.20, combined with Oxide of Tantalum 60.66, has recently been analysed by Berzelius. The hardness and external characters of this ore nearly agree with those of tantalite. Its specific gravity is 6.29. A similar ore has also been found at Bodenmais in Germany.

CHROMIUM AND SELENIUM.

Chromium is found combined with oxygen in three proportions, forming a green oxide, a brown oxide, and a red oxide, which has the properties of an acid. In these different states, it constitutes the colouring matter of some minerals. Chromic acid is found combined with lead and iron. (See Chromate of Lead, and Chromate of Iron.) There are not properly speaking any ores of chromium, though it occurs in the proportion of ten per cent. as the colouring-matter of certain minerals.

Selenium. — In the sulphur obtained from pyrites at Fahlun, Berzelius has lately discovered a substance which has many of the properties of a metal, but it melts at a temperature somewhat exceeding that of boiling water, and burns when a flame is applied to it, emitting the odour of horse-radish. When melted and gradually cooled, it remains long in a semi-fluid state, and is extremely tenacious, and may be drawn out into threads like Spanish wax. This substance Berzelius has called selenium; it combines with oxygen, and forms an acid, which he calls the selenic acid.

Wodanum and Cadmium. — Of the new metal called *wodanum*, little is at present known; and it is not ascertained whether the metal Cadmium occurs in any of the zinc ores in Britain. See Zinc.

AN

INTRODUCTION

TO

MINERALOGY.

BOOK IV.

NATURAL HISTORY AND CHARACTERS OF COMBUSTIBLE MINERALS.

Essential Characters.

Specific Gravity under 2½, except the diamond.
Soft, yielding easily to the knife, except the diamond.
Burn away at or below a red heat, except the diamond, plumbago, and mellite.

Genus I. — SULPHUR.
Genus II. — CARBON.
Genus III. — CARBON and HYDROGEN.
Mellitic Acid?

GENUS I. — SULPHUR.

SULPHUR is found in a native state, nearly pure in the mineral kingdom; it is frequently combined with iron and other metals; it also occurs united with oxygen, forming sulphuric acid, in which state it is a constituent part of gypsum, and of various alkaline and metallic salts. Native sulphur is found most plentifully in or near the craters of dormant volcanoes, and from the immense volumes of sulphureous vapour emitted during volcanic eruptions, we may infer that sulphur forms one of the principal supporters of volcanic fire, and that it exists abundantly in the internal part of the globe. We know not, however, whether sulphur exists there as a simple substance, or whether it may not be formed from more simple elements, by the very processes which produce volcanic eruptions. The sulphur found in volcanic craters is not deposited during the active state of a volcano, but is sublimed afterwards, and appears generally to be formed by the decomposition of hydrogen gas, holding sulphur in solution, called by chemists sulphuretted hydrogen.

Sulphur is found lining the cavities or fissures of lava, either in a pulverulent state, or forming incrustations, or in irregular masses attached to the sides of rocks; it also occurs stalactitical, and in globular concretions, and sometimes regularly crystallized. Sulphur is found also in large masses near the surface of the soil, in the vicinity of volcanoes, and may be procured in considerable quantities from almost every volcanic country. The principal mines of sulphur in Europe are, the Solfaterra near Naples, and those of Sicily. Sulphur is obtained from the island of Teneriffe, and from the volcanic islands in the West Indies, particularly Guadaloupe and Martinique.

Sulphur is frequently found in small quantities disseminated in gypsum, probably produced by the decomposition of the sulphuric acid of that mineral. According to Dolomieu, there are continuous strata of sulphur from ten to twenty feet thick, alternating with gypsum and rock-salt in the valley of Mazzaro, in Sicily. Though Dolomieu says the strata are continuous, they must be irregular; for he informs us, that the miners in sinking, do not previously know whether they shall meet with rock-salt or sulphur. Sulphur is often deposited in crusts on the surface of the soil, by sulphureous springs, like those of Harrowgate in Yorkshire.

SP. 1. NATIVE SULPHUR. — The colour is greenish or reddish-yellow; when impure it is grey or brown. The lustre is glistening and resinous; it is opaque or translucent. The crystallized varieties are semi-transparent, or transparent, and refract doubly.

Sulphur yields to the knife, and is easily frangible; the fracture is uneven or imperfectly conchoidal. It becomes negatively electric by rubbing, and emits a faint sulphureous odour. Its specific gravity is 1.99, or sometimes rather exceeding 2. Sulphur may always be recognized by the blue colour of its flame, and the peculiar odour which it emits when lighted.

Crystallized Sulphur. — The primitive crystal of sulphur is an acute octahedron, formed of two pyramids, with scalene triangular faces (Plate IV. fig. 30.), in which the angle formed by the incidence of the planes at their common base is 143° 7′, and the angle at the apex 36° 53′. A secondary form derived from the above is represented fig. 37. —(*souffre prismé*). Haüy enumerates eight secondary forms. The surface of the crystals is smooth and shining; their lustre is sometimes adamantine; the crystals are generally small.

Volcanic Sulphur has the same properties as the native-sulphur found in gypsum. It is much purer than the sulphur obtained by sublimation from pyrites; the latter almost always contains a portion of arsenic or other metallic matter; hence the sulphuric acid manufactured from it, is unsuited for various purposes in the arts, and is particularly unfit for the use of the bleacher.

GENUS II. — CARBON.

Sp. 1. *Diamond.*
2. *Graphite.*
Sp. 3. *Anthracite.*
Mineral Charcoal.

Though carbon is a principal constituent ingredient in all vegetables, it is found in the highest state of perfection in the mineral kingdom. The diamond, according to the analyses of the most distinguished chemists, is pure crystallized carbon. Carbon is also found nearly pure in graphite or plumbago (black-lead), and in a variety of coal that burns without flame or smoke, called anthracite; and also in mineral charcoal. All the above minerals are comparatively of rare occurrence, and are found in small quantities. Carbon combines with oxygen, and in the state of carbonic acid, is a constituent part of mountains and strata of lime-stone of vast extent and magnitude. Lime-stone, when pure, is composed of 45 parts of carbonic acid, and 55 lime, and therefore contains one-eighth part of carbon.

Sp. 1. DIAMOND. — The diamond is the hardest substance in the mineral kingdom; it will cut or scratch the sapphire, and every other gem. It is found in detached crystals and in crystalline pieces or grains. The diamond is generally transparent or semi-transparent and colourless, or nearly so; but it sometimes occurs of various shades of grey, and more rarely blue, red, yellow, green, brown, and even black; diamonds of the latter colour are nearly opaque. Externally the diamond is generally splendent, but sometimes it is rough and glimmering; the lustre internally is always highly splendent. The diamond has a very high degree of refractive power, a property possessed by all combustible transparent substances, whether fluid or solid; hence Newton was led to infer that the diamond was a combustible substance, an inference which subsequent experiments have fully confirmed. It does not refract doubly. The diamond has a very distinct laminar structure, yielding with facility to mechanical division, in four directions parallel to the planes of a regular octahedron, which is the primitive form; sometimes each plane of the octahedron is divided into six faces, which are somewhat convex, as represented Plate IV. fig. 29. The diamond also occurs crystallized in various modifications of the octahedron, and in cubes and dodecahedrons, and sometimes in six-sided prisms and hemitrope crystals or macles. In the Greville collection at the British Museum, there are nine modifications of cubic diamonds; and in the collection belonging to Mr. Lowry, of London, there are other modifications of the cube, and some unique and extremely interesting crystallizations of the diamond.* The specific gravity of the

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* Of Mr. Lowry's collection of diamonds, the celebrated crystallographer Le Count de Bournon gives the following description: — "La collection de M. Lowry, artiste du premier merite, a eté formée parlui même, et renfirme un grand nombre de varietes extremement precieuses, dont plusieurs sont uniques. Cette collection ansi que celle qu'il a rassembleés dans les divers autres parties de la mineralogie, fait autant d'honnuer a ses connoisse~~urs~~ances dans cette science, que ses ouvrages en font, a son habilité dans la partie de l'art de gra-

diamond is 3.488 (Lowry); 3.51 to 3.55 (Haüy). At a white heat it gradually burns away, and in oxygen gas is converted into carbonic acid gas, affording a satisfactory proof that it is entirely composed of pure carbon. By some chemists, it has been supposed that the diamond contained a portion of hydrogen. The diamond acquires positive electricity by rubbing, whether the surface be rough or smooth. Many diamonds absorb the rays of light, and are phosphorescent when carried into a dark room; but all diamonds do not possess this property.

Distinctive Characters. — Diamond may be distinguished from transparent zircon and sapphire, by its inferior specific gravity; that of zircon being from 4.5 to 4.7, and of sapphire 4. The diamond has a higher degree of hardness and lustre than any other of the precious stones. See Table I. Book II. pp. 204 and 205.

Diamonds are found in ferruginous sand and gravel, which form the beds or banks of rivers in various parts of the Indian peninsula, from Bengal to near Cape Comorin, particularly in Golconda and Visapore. Diamonds are also found in the island of Borneo.

I was informed by an intelligent military gentleman of high rank, who visited some of the diamond mines in India, that the diamonds are found in a bed of pebbles or gravel at a small distance below the surface. The workmen dig and throw away carelessly all the

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ure, à laquelle il se livre."—(Catalogue de la Collection Mineralogique, p. 150.) — Lessons on Mineralogy are given by Mrs. Lowry, Titchfield-street, illustrated by the valuable collection of minerals so justly and highly praised by the Count de Bournon.

materials until the water begins to appear, they then examine every stone one by one, holding it between the eye and the light.

Diamonds have, during the last century, been obtained in considerable quantities from the Brazils. Mr. Mawe informs us, in his Travels in the Brazils, that the diamond mines are situated due north of the mouth of the Rio Janeiro. The principal river from which diamonds are obtained is a shallow and broad stream, called the Jigitenhona, the waters of which being turned aside or dammed out, the mud at the bottom is first removed, under which is a stratum of rounded pebbles and gravel. In this gravel, the diamonds are found and separated by washing them with great care. Diamonds are also found in various parts of the district, and on the summits of some of the mountains.

Diamonds are valued by their weight in carats; a carat being equal to four grains. The value increases as the squares of their respective weights: thus, if a diamond of one carat be worth 8*l.* one of two carats will be worth 32*l.* equal to the square of two, *viz.* four multiplied by eight; the value of a diamond of three carats is equal to nine by eight, or 72*l.* &c. &c. About one-half the weight of the diamond is cut away by the lapidary, and the quantity of diamond-powder used in polishing a very large diamond has sometimes cost one thousand pounds sterling. In the British Museum, there is a model in lead of the Pigot diamond, before it was cut, and also of the various cuttings by which it was reduced to its ultimate form. The largest diamond in Europe weighs 193 carats, and is the size of a pigeon's egg; it was stolen from the eye of a Malabar idol by a common soldier, and passed through various hands before it was purchased by Count Orloff for the late Empress of Russia. The largest diamond in the world is said to have been found in the island of Borneo, and to be now in the possession of the Rajah of Mattan; it weighs 367 carats.

SP. 2. PLUMBAGO, or GRAPHITE. (Vulg. BLACK-LEAD.) — The colour of this mineral is dark lead-grey, or iron-grey. The lustre glistening and metallic. It occurs amorphous and nodular. Plumbago feels unctuous, and is soft and perfectly sectile; it soils strongly, forming a distinct lead-coloured mark on paper. At a white heat it burns away, leaving a small portion of red oxide of iron. According to Berthollet, it contains — Carbon 89.9, Iron 9.1.

SCALY PLUMBAGO has a curvedly lamellar structure. This variety has lately been found imbedded in gneiss, at Glen-Strathfarren, near Beuly in Inverness-shire. It is much inferior in quality to the plumbago of Cumberland.

Plumbago is found in France and Spain, and in various parts of the United States. The most esteemed plumbago in Europe is obtained from a mine near the village of Seathwaite in Borrowdale, in Cumberland. The plumbago occurs in an irregular pipe vein, which is only found productive where cross veins enter it. The vein occurs in a rock of grey felspar porphyry, which in a distant part of its range, passes into compact red felspar and clink-stone. The plumbago is found in irregular masses, imbedded in a ferruginous and unctuous clay accompanied by calcareous spar and green-earth. In no part of the Borrowdale range, that I have examined, is there any green-stone or amygdaloid, as has been recently stated. The finest plumbago of Borrowdale is sold from 36*s*. to 40*s*. per pound. *

Sp. 3. ANTHRACITE, BLIND-COAL, CULM. — This mineral forms the connecting link between plumbago and common mineral coal, sometimes passing into the former, and sometimes into the latter. Its colour is greyish or brownish-black; the lustre shining, and between resinous and metallic; it burns without flame or smoke. The fracture is conchoidal or slaty. Anthracite is soft, and easily frangible. The specific gravity varies from 1.52 to 1.80. This species of coal occurs in some parts of South Wales, adjoining the Bristol Channel; at Cumnock, in Ayrshire; and at Kilkenny, in Ireland. At Cumnock there is a bed of anthracite from three to six feet in thickness, which is columnar like basalt, and appears to pass into plumbago. Anthracite contains from 72 to 90 parts of Carbon, intermixed with Silex, Alumine, and Oxide of Iron.

Mineral Charcoal is of a greyish-black colour; it occurs in thin layers, between beds of coal; it has a woody fibrous structure, and a silky lustre; it stains the fingers, and burns without smoke or flame, like common charcoal.

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* Some of the clay-slate in Borrowdale contains cavities filled with calcareous spar, but is not a basaltic amygdaloid; — it is in fact a grey wacke with nodules of calcareous spar in place of quartz.

GENUS III.—CARBON AND HYDROGEN.

SP. 1. *Liquid Bitumen.*
Naphtha.
Petroleum.
Maltha.
Asphaltum.
2. *Mineral Coal.*
SP. 3. *Jet.*
4. *Wood Coal.*
Amber?
Retinasphalt?
Highgate Resin?
Mellite?

CARBON, in combination with hydrogen, forms all the different varieties of coal and bitumen; some of these present certain indications of a vegetable origin, and we may trace the different gradations from peat and wood, buried in swamps (called lignite), to wood-coal and jet. The latter has a strong resemblance to mineral-coal, and was supposed to pass into it; but Dr. Macculloch has shown, that there is an essential difference between all these substances and true mineral-coal. The blackest and most compact peat, wood-coal, or jet, will yield acetic acid, or vegetable principles by distillation, which mineral-coal will not do under any circumstances.

According to the views of this philosopher, water is capable of bituminising vegetable matter to a certain extent, that is, of converting it into a substance approaching to the nature of coal, and containing bitumen; but for its conversion into true mineral-coal, some further process is required; and Dr. Macculloch has shown by a direct experiment, that this may be effected by heat, under a compression sufficient to prevent the escape of the more volatile principles. *

"It has been customary to regard coal as a combination of carbon and bitumen, but as the latter is itself composed of carbon and hydrogen, it is more accordant to nature, to regard coal as a bitumen, varying in its proportion of carbon, from the fattest Newcastle coal, to the driest blind-coal that burns without flame or smoke. The bitumens vary in their proportion of hydrogen, from naphtha, which is the lightest, and contains the most of that element, to petroleum and mineral pitch, in which the proportion of carbon is increased, and we may trace the gradation through the different varieties of coal, to anthracite which contains only carbon. Coal owes its compactness to the peculiar circumstances under which it has been formed, the changes it may have subsequently undergone, and the substances with which it is intermixed." In describing the following carbonaceous minerals, I shall begin with liquid bitumens, including those which become fluid at a low temperature.

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* See a valuable paper on coal in the 2d vol. of the Transactions of the Geological Society, by Dr. Macculloch. This paper contains, I conceive, the most correct and comprehensive view of the nature of carbonaceous minerals, that has ever been published.

Sp. 1. LIQUID BITUMEN, NAPHTHA, resembles oil, being perfectly fluid and transparent, and has a light yellowish colour inclining to brown; it feels unctuous, and has a strong peculiar odour; it burns with a white flame on the approach of a lighted taper. Naphtha swims when poured upon water. Its specific gravity is 0.7.

Naphtha springs from certain strata in Persia and Japan. It occurs in France and various parts of Italy. It is composed of carbon and hydrogen; when the latter principle is diminished, it passes into petroleum.

PETROLEUM is less fluid than naphtha; its colour is brownish or reddish-black; it will burn with a wick like oil. Petroleum frequently issues from the sand-stone strata that alternate with coal. It occurs abundantly in Shropshire, and in various parts of Europe.

MALTHA, OR EARTHY MINERAL PITCH, has a blackish-brown colour; is soft and sometimes semifluid: when solid, the fracture is earthy; the lustre is dull or glimmering; the streak is resinous; it has a strong bituminous odour, and burns with a bright flame; it occurs sometimes in metallic veins.

ELASTIC BITUMEN has a blackish-brown or greyish-brown colour, and is translucent on the edges. It yields to the impression of the nail, and is elastic. It occurs in nodular masses, in a vein at the Odin mine in Derbyshire.

ASPHALTUM, COMPACT MINERAL PITCH, *Bitume Solide*. — This mineral is solid and generally brittle; the colour is black, or brownish-black; some varieties have a conchoidal fracture and a resinous lustre. Asphaltum is opaque; it does not yield any peculiar smell, until rubbed or heated; it burns freely, and leaves but little residue. Asphaltum floats on the waters of the Dead Sea in Judea. In the Island of Trinidad, the celebrated Pitch lake, three miles in circumference, is incrusted with a stratum of asphaltum. Asphaltum occurs sometimes in mineral veins.

Sp. 2. COMMON MINERAL-COAL, *Houille.* — This well-known mineral has a black colour, a shining or glistening lustre, inclining to resinous; it has a stratified or thick slaty structure; the cross fracture varies in different varieties, passing from uneven to even and conchoidal; it is brittle and easily frangible. The specific gravity varies, according as it is more or less pure. A cubic yard of good coal is calculated to weigh a ton, but coal sometimes contains so much pyrites and earthy matter, that the cubic yard would weigh 29 cwt. This is the case with some coal in the vicinity of Manchester, a circumstance not sufficiently attended to by the purchasers of coal by weight. The specific gravity of good coal varies from 1.28 to 1.33. The mineral-coal of England may be classed under three varieties — soft-coal, hard-coal, and kennel-coal.

Soft Coal, or Caking Coal, contains much petroleum, which oozes out by heat, and causes the small pieces to cohere in one mass; it often alternates with common coal. When coal possesses the caking property, it can be burned for coke with advantage, as the small coal forms firm adhering masses of considerable size.

HARD-COAL, or SLATE-COAL, burns without caking, and forms a white ash. A great part of the coal of Staffordshire, Leicestershire, and Derbyshire, is of this kind. The coal of Northumberland or Durham is principally caking coal.

KENNEL-COAL, CANDLE-COAL. — This variety has a stratified structure, but the cross fracture is flatly conchoidal or even; the colour is generally lighter than that of common mineral-coal, and the lustre faint; it does not soil the fingers, and burns with a bright white flame and a crackling noise. It occurs in Lancashire and Staffordshire.

Common mineral-coal occurs in strata varying from a few inches to several feet or yards in thickness, and alternating with strata of sand-stone and shale. The strata are generally depressed in basin-shaped concavities, and a great number of beds and seams of coal frequently lie over each other at different depths, separated by different earthy strata. The deepest coal-mines in England are worked three hundred feet below the surface. The limits of the present work prevent a further description of the geological relations of coal. Some of the Staffordshire coal, near Dudley, is evidently composed of vegetable laminæ compressed and converted into true mineral-coal. I must refer those readers desirous of further information to my Introduction to Geology, chap. viii. South Wales, Staffordshire, Northumberland, and Durham, are the principal repositories of coal in South Britain. Coal abounds in some parts of France, and in various northern countries in Europe; also in China, Japan, and on the western side of the Alleghany Mountains in the United States.

Sp. 4. JET, *Jayet*, Fr. *Pechkole*, Werner. — The colour is velvet-black; the structure evidently ligneous; it passes into wood-coal; the colour is then a brownish-black. Jet has a shining resinous lustre, and does not soil the fingers. The fracture is conchoidal; it yields easily to the knife, and burns with a greenish flame and bituminous odour. Jet acquires resinous electricity by rubbing. Its specific gravity is about 1.25. Jet occurs massive, and in branches which have an internal woody structure. It is found along with mineral-coal in some of the coal-mines in Scotland, and in alum-shale at Whitby in Yorkshire.

Sp. 4. WOOD-COAL, BROWN-COAL, BOVEY-COAL. — The colour varies from brown to brownish-black; it occurs massive, with a vegetable structure; the cross-fracture is imperfectly conchoidal. Wood-coal yields easily to the knife; it burns with a disagreeable odour. Some varieties are soft from decomposition, others contain much earthy-matter and pyrites. Wood-coal occurs in low situations and in alluvial soil, and is evidently formed by the bituminization of wood or vegetable matter. The wood-coal at Bovey Heathfield, in Devonshire, occurs in irregular beds, alternating with what the workmen call *dead coal*, which is less inflammable, and resembles shale. The coal is worked open like a quarry. The mine is at the feet of Dartmoor, on the edge of a low plain, which probably has once been a lake. The change from the submerged wood found in many peat-moors, into wood-coal, may be distinctly traced.

It may be doubted, whether the three following substances belong to the mineral or the vegetable kingdom.

AMBER occurs in small irregular masses and plates, which are translucent or transparent, and are of various shades of yellow; the texture is compact, and the lustre shining or glistening. Amber acquires negative electricity by rubbing. Its specific gravity is about 1.08; it burns with a yellow flame, and a fragrant odour, intumescing, but not melting. Amber is brittle, and yields easily to the knife. Amber is found in alluvial soil near Koningsberg, where it occurs in bituminised wood; it is also thrown up by the sea on the coasts adjoining the Baltic. Amber has been found in alluvial soil in some parts of the United States.

RETINASPHALT is opaque and of a yellowish-brown colour; it occurs in small irregular pieces in the wood-coal at Bovey. When held to a candle, it burns with a bright flame and a fragrant odour. The specific gravity is about 1.10. When broken, the lustre is glistening and resinous. It contains — Resin 55, Asphalt 42, Earth 3. Hatchett.

HIGHGATE RESIN. — This substance was found in small pieces in blue clay, at Highgate near London. The colour is yellowish-brown; the lustre is resinous, and it is translucent; when heated it emits a fragrant odour; it is brittle and yields easily to the knife. It melts into a limpid fluid, and burns away before the blow-pipe.

The two last substances appear to be vegetable resins partially changed by being long buried in the earth.

MELLITE, HONEY-STONE. — This mineral, composed of a peculiar acid combined with alumine, has hitherto been found only in bituminous wood at Aerteon in Thuringia, and Langenhogen in the Circle of Saal. The colour is honey-yellow; it is translucent and semi-transparent, and refracts doubly; the lustre shining, and between resinous and vitreous. Mellite occurs in angular pieces and grains, also crystallized in small octahedrons and four-sided prisms; it is softer that amber, and is brittle and easily frangible. Its specific gravity is about 1.58.

Before the blow-pipe it becomes opaque, and is reduced to ashes: when heated in a close vessel it becomes black. It contains—Mellitic Acid 46, Water 38, Alumine 16.

AN

INTRODUCTION

TO

MINERALOGY.

BOOK V.

NATURAL HISTORY AND CHARACTERS OF SALINE MINERALS.

Essential Characters.

Soluble in Water.
Taste Sapid.

Genus I. — MURIATES.
Genus II. — NITRATES.
Genus III. — SULPHATES.
Genus IV. — CARBONATES.
Genus V. — BORATES.

OBSERVATIONS ON SALINE MINERALS.

Native soluble salts, with the exception of common salt, rarely occur in large masses, or form rocks or strata of any considerable extent. Many native salts are daily forming by processes which are taking place in the atmosphere, or near the surface of the earth; some of the native soluble salts abound in various mineral waters. The investigation of their properties belongs rather to the Chemist than the Mineralogist. It will be sufficient to take a brief notice of them.

GENUS I. — MURIATES.

Muriatic acid is an abundant substance in nature, but is principally found combined with soda, forming rock-salt, either solid or dissolved in the waters of all seas. Muriatic acid also occurs combined with ammonia, in the vicinity of volcanoes, forming the salt called sal ammoniac. Most of the sal ammoniac of commerce is, however, obtained by artificial processes.

SP. 1. ROCK-SALT, or COMMON SALT. — The colours of this well-known salt are generally white, grey, or red; it sometimes occurs of various colours, as blue and green; the blue varieties are clouded. Rock-salt varies from transparent and translucent to opaque; the lustre is shining and vitreous; it occurs massive, stalactitical, and crystallized, in cubes, in cubo-octahedrons, and octahedrons. The structure is indistinctly laminar; it breaks easily into cubic fragments, the cube being the primitive form. The specific gravity is 2.14; it yields easily to the knife. When exposed to the air, it deliquesces in moist weather. The taste is the same as of common culinary salt. Rock-salt contains — Muriatic Acid 46.55, Soda 53.44. Berzelius. According to Sir H. Davy, it is composed of Sodium and Chlorine. The purest rock-salt of Cheshire yielded (Dr. Henry) in a 1000 parts, Muriate of Soda 983, Sulphate of Lime $6\frac{1}{2}$, Muriate of Magnesia $0\frac{3}{18}$, Muriate of Lime $0\frac{1}{16}$, Insoluble Matter 10.

The rock-salt of Cheshire near Northwich occurs in two beds, the uppermost is forty-two yards below the surface, and twenty-six yards thick; this bed was discovered about 140 years since, in searching for coal. The lower bed is separated by a stratum of marl about ten yards thick; it has been worked to the depth of forty yards, but is not sunk through. The breadth of the beds is about 1400 yards; the length N.E. and S.W. has not been ascertained. In another part of Cheshire, three beds of rock-salt have been found. There are also numerous brine-springs in that county, the waters of which are nearly saturated with salt. The existence of rock-salt at Droitwich in Worcestershire, has been ascertained by boring, but all the salt manufactured there is procured from the springs which rise to the surface. The most celebrated salt-mines in Europe are at Cardona in Spain, and in Poland. The former appears to be an enormous mass of salt that probably once formed the bottom of a lake. Through this mass the water has excavated a valley, leaving several detached mountains of salt that were probably harder than the other parts. There is an extensive formation of rock-salt on each side of the Carpathian mountains, for 600 miles from Welieska in Poland, to Rimnic in Moldavia. Rock-salt and salt-springs most generally occur near the feet of extensive mountain-ranges, which adds probability to the opinion, that these ranges were once the boundaries of extensive lakes of salt-water.

Rock-salt occurs abundantly in various parts of Asia, Africa, and America. In some parts of Africa, there are salt-lakes which rest on beds of solid rock-salt; these beds were probably formed by fresh depositions of salt as the water evaporates. Near Algiers, the salt-lakes are dried up in summer, and leave immense masses of rock-salt at the bottom.

The waters of the sea contain about 2½ per cent. of salt. According to La Place, the average depth of the ocean is ten miles; were the water evaporated, the salt would form a bed of 700 feet in thickness, a mass equal to cover all the present dry land with salt to the depth of 2000 feet. And as the ocean has once covered our present continents, we need not be surprised at the quantity of rock-salt found in various parts of the globe.

Beds of rock-salt are almost always accompanied by beds of gypsum. The constant occurrence of the muriatic and sulphuric acids in the same situations, is an interesting fact, which in a more advanced state of chemical and geological science, may serve to elucidate the formation of gypsum and rock-salt.

Sp. 2. MURIATE of AMMONIA, SAL AMMONIAC. — This salt is found in the craters of volcanoes, and in coal-mines that have been on fire; it occurs massive, incrusting, and crystallized, in octahedrons. The structure of massive sal ammoniac is fibrous. This salt when pure is white; the taste is peculiarly pungent and acrid.

Genus II. — NITRATES.

Sp. 1. NITRE, NITRATE of POTASH, SALTPETRE. — This salt occurs forming incrustations, and in groups of capillary crystals; the taste is cooling and saline; it may be known by its property of deflagrating when placed on a hot coal. Nitre is formed on the surfaces of walls and rocks by atmospheric processes, with which we are at present unacquainted. The soil in many parts of the world is impregnated with nitre; it also forms thin crusts upon the surface.

Genus III. — SULPHATES.

Sp. 1. *Native Alum.*
2. *Sulphate of Magnesia.*
Sulphate of Soda.
4. *Sulphate of Iron.*

Sp. 5. *Sulphate of Copper.*
6. *Sulphate of Zinc.*
7. *Sulphate of Cobalt.*

The combination of sulphuric-acid with the alkalies, and with alumine, magnesia, and some of the metals, forms soluble native salts, all of which, except sulphate of soda, are precipitated from their solutions by carbonated alkalies. The sulphates occur in very small quantities solid; they are often found in solution, in mineral waters, and waters issuing from mines.

Sp. 1. NATIVE ALUM. — This salt sometimes forms an efflorescence, or occurs in capillary crystals on aluminous rocks, and on the surface of lava. It has a sweetish but harsh acidulous taste. Alum crystallizes from its solutions in regular octahedrons.

Sp. 2. SULPHATE of MAGNESIA, EPSOM SALT. — This salt, though contained in various mineral waters, is seldom found solid; it sometimes occurs in fibres and acicular crystals; it has a peculiarly bitter taste.

Sp. 3. SULPHATE of SODA, GLAUBER SALT. — This salt sometimes forms efflorescent incrustations, but has not been discovered massive. It occurs in various mineral waters; the taste is saline. A salt containing a mixture of sulphate of soda and sulphate of potash with muriates of soda and ammonia has been found on the cone of Vesuvius, and has been called *compound anhydrous salt*, but such mixtures may be considered as accidental, and can have no claim to rank as species. An efflorescent substance, which is a mixture of sulphate of soda and magnesia, has been found in the country round Sedlitz, and called Reussite.

Sp. 4. SULPHATE of IRON, GREEN VITRIOL.—The colours of this salt are various shades of green or yellow. It is found in iron-mines and coal-mines, massive, crystallized, stalactitical, and disseminated, and appears generally to be formed by the decomposition of pyrites. The crystals are acute rhomboids. It contains — Oxide of Iron 25.7, Sulphuric Acid 28.9, Water 45.4. Berzelius. Solutions of this salt are changed into black ink by gallic-acid; with prussiate of potash they immediately yield a blue precipitate.

Sp. 5. SULPHATE of COPPER, BLUE VITRIOL. — This salt is distinguished by its bright-blue colour, and the blue solution it forms with water. It is found in various copper-mines amorphous, stalactitical, and pulverulent, but occurs more abundantly in solution. Solutions of sulphate of copper deposit a coat of metallic copper on the surface of iron. It contains — Oxide of Iron 32.13, Sulphuric Acid 31.57, Water 36.30.

Sp. 6. SULPHATE of ZINC, WHITE VITRIOL. — This salt is found in some mines containing sulphuret of zinc, from the decomposition of which it appears to have been formed. It occurs amorphous, stalactitical, crystallized, and capillary, also forming incrustations. The colour is yellowish-white; the taste is nauseous and metallic. It contains — Oxide of Zinc 27.5, Oxide of Manganese 0.5, Sulphuric Acid 22, Water 50. Klaproth.

Sp. 7. SULPHATE of COBALT, RED VITRIOL. — The colour of this salt is flesh-red or rose-red. It occurs incrusting and stalactitical in the refuse thrown out of cobalt-mines. It is opaque, and the taste is styptic Its solution affords a blue precipitate with carbonate of potash. The precipitate tinges borax blue.

GENUS IV. — CARBONATES.

The only solid soluble salt in the mineral kingdom belonging to this genus is the carbonate of soda. The insoluble carbonates are described in Books II. and III.

SP. 1. CARBONATE OF SODA, NATRON.— This salt is found forming an efflorescence, or a solid incrustation on the surface of the soil, or on certain rocks; it is also found on the sides and bottoms of certain lakes that become dry in summer. The colours are yellowish or greyish-white. When compact, the structure is granular or radiated, and the lustre vitreous. By exposure to the weather, it becomes dull, friable, and opaque. It effervesces violently with acids. It is composed of the sub-carbonate of soda mixed with variable proportions of other salts. It is found abundantly in various parts of Hungary, and in Egypt.

GENUS V. — BORATES.

SP. 1. *Boracic Acid, Sassolin.* | SP. 2. *Borax.*

SP. 1. BORACIC ACID, or SASSOLIN. — This salt has been obtained on the borders of hot springs, near Sasso in the Florentine territory. It occurs forming incrustations and in small friable pieces which appear composed of minute grains or scales that adhere slightly to the finger. The colours are white, or yellowish-white. The taste is harsh and sub-acid. It is easily fusible, forming a transparent globule. The constituent parts of this salt are — Boracic Acid 86, Sulphate of Magnesia with Iron 11, Sulphate of Lime 11. Klaproth.

Sp. 2. BORAX, *Soude Boratée*, Haüy. — Borax is dissolved in the waters of many springs in Persia and Thibet; it is also found in those countries, forming solid incrustations and crystallized. The primitive form is a rectangular prism, but it is commonly crystallized in six-sided prisms, more or less compressed. The colours are greenish-white and greenish-grey. The lustre internally is shining and resinous; it is semi-transparent, and refracts doubly. Borax has a sweetish acrid taste. The specific gravity is from 1.56 to 1.70. It is soft and easily frangible. The constituent parts are — Boracic Acid 37, Soda 14.50, Water 47. The borax of commerce is brought to Europe from Thibet in an impure state, and is called Tincal. The purification is performed by the Dutch. This salt is eminently useful to the metallurgist and mineralogist, being a powerful flux.

ADDENDA, No. I.

The following names have been given to certain minerals, of which little is at present known: most if not all of them are probably varieties of known species. It will be sufficient to enumerate them.

Pseudo-Sommite, in small regular hexahedral crystals; from the Cap de Bovo; it gelatinizes in nitric acid, and accompanies the following mineral.

Mellilite, in small yellow or orange-coloured rectangular crystals; gelatinizes in nitric acid.

Spinellane, in small blueish-brown crystals, from the mountains of the Lower Rhine.

Spinthese, in small irregular dodecahedrons. Haüy.

Chusite, and Limbilite, found in a volcanic rock near Limburg. Saussure.

Chrichtonite, a variety of titanite.

Gehlenite, found in the valley of Fassa, supposed to be idocrase.

Sideroclept, found in volcanic rocks near Brisgau. Saussure.

Succinite, in small hard yellow globules, found in the valley of Laus in Piedmont.

ADDENDA, No. II.

ON THE APPLICATION OF GEOMETRY TO CRYSTALLOGRAPHY.

In the theory of the formation of crystals of M. Haüy, of which some account has been given in Book I. chap. 5, 6, and 7. it is supposed that crystals increase by the application of thin plates or laminæ applied to their surfaces, called laminæ of superposition. If the laminæ are applied to each face so as completely to envelope the crystal, it may continue to increase in size without changing the form; such crystals are called primary. If the laminæ of superposition cover only a part of the primary crystal, a change of form will take place, and a secondary crystal will be produced. In this theory it is further supposed, that each lamina or plate is composed of rows or ranges of integrant or subtractive molecules, each of which is of a determinate figure. In parallelopipeds, the integrant or the subtractive molecules have the same form as that of the primary crystal. In the formation of secondary crystals, one or more rows of these molecules are taken away from the edges or angles of each of the laminæ as they are successively applied to the surface.

A crystal may therefore be regarded as a solid, bounded by plane surfaces, and increasing by the application of laminæ or plates, composed of ranges of molecules of a determinate form. When these are known, we are enabled by the aid of geometry, to ascertain all the forms that can possibly be produced by the application of successive laminæ, decreasing by any given number of ranges in a given direction. By geometry, we are also enabled to ascertain the true proportions of all the sides and angles of the primitive crystal, when certain sides or angles are given. We can thus verify our first admeasurements by bringing them to the unerring standard of mathematical demonstration.

Many persons have probably been deterred from entering on the mathematical part of Haüy's theory, by the algebraic formulæ in which the demonstrations are clothed.

Nothing more is, however, required for a knowledge of the principles of crystallography, than an acquaintance with the elements of geometry and of plane trigonometry. I shall briefly endeavour to show their application to the measurement of crystals, and to determine the laws by which some of the secondary crystals are produced. For this purpose, I shall select a few of the simplest forms and cases, which I trust will enable the student to perceive the important aid that crystallography derives from geometry, and also to comprehend in what manner Haüy discovered the laws of decrement in more complex cases, and in some degree to judge of the accuracy of the principles on which his theory is founded. I trust also that the cases selected may be useful as an introduction to the more elaborate parts of that theory.

The simplest form of a crystal that can be selected is the cube, the sides and opposite angles being all equal. Let A A, B B, Plate I. fig. 8. represent the cubic nucleus, and A A the upper edge: let 1, 2, 3, represent a series of laminæ, each decreasing by one range all round; this will form a four-sided pyramid on the upper face of the cube.

It is required to know, what will be the angle formed by a decrement of one range of cubic molecules in breadth on the edges of the cube; or, in other words, what angle the faces of the pyramid will form with the sides of the cube?—Answer 135°.

For the molecule *a*, fig. 8. being distant from the edge A of the nucleus, by a space equal to its height, the line *c*, which measures the angle of inclination of the new face, will make an angle of 45° with the base A A, or half a right angle; this being added to the angle A of the nucleus, gives 135° for the angle formed by a decrement on the edges of one in breadth on one side of the cube.

If we suppose the lower line B B to represent the upper edge of any cubic nucleus, on which decrements take place by ranges of two molecules in height, in this case, the edges of the molecules 2, 2, 2, will form the face of the secondary crystal. It would be easy to demonstrate, that the angle formed by this face with the line B B, is equal to 60°; this new face will, therefore, form an angle with the perpendicular plane or side of the cube of 150°.

In this manner, we may demonstrate all the forms and all the angles that can be possibly produced by any decrements of cubic molecules on the edges of the cube, as they resolve themselves into cases of right-angled triangles which admit of the simplest solutions.

When the primitive form and the integrant molecules are cubes, the distance of the laminæ from the edge on which the decrement takes place, is equal to the length of the sides of as many molecules as there are ranges taken away in that direction, because in the cube the length of each of the sides is equal to the breadth and height; but in other parallelopipeds where the sides or angles are unequal, the proportion of the breadth and height of a molecule, and the distance between the edge of the first lamina, and that of the nucleus, can only be determined by calculation.

If we suppose fig. 12. to represent either a primitive crystal, or a rhomboidal molecule, the line A B measures the length of its side, but the true breadth or height of the molecule is measured by the line A X, or A Y, perpendicular to D A, and in calculating the ranges of molecules taken away, it is therefore the line A X, which is the measure of one range of molecules in breadth or height. Now the proportion which this bears to the side A B, or B D, must be discovered by geometry; we shall, therefore, proceed to determine this and other properties of the rhomboid.*

Prop. Given the obtuse plane angle of any rhomboid whatever. It is required from thence,

1. To ascertain the acute angles.
2. To ascertain the proportions of the greater and lesser diagonals of the rhomb to each other, and to the sides.

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* By a rhomboid, Haüy always means a figure bounded by six equal rhombic planes, parallel two and two: figs. 12 and 13 being drawn in perspective, the equality of the sides cannot be shown.

3. To determine the breadth A X, or its proportion to the sides A B, A D, &c.

4. To ascertain the solid angle formed by the incidence of the sides of the rhomb, *viz.* the angle made by the face B A D P, with the face A D C L, &c.

5. To ascertain the solid angle at the summit of the rhomb, or, in other words, the angle formed by the edge A D with the line A K, fig. 12.

Then 1*st. To ascertain the acute plane angles.*

Let us take the rhombic face B A P D, of which the plane obtuse angle A is known, which we will say is equal to a given quantity, called a; then draw the diagonals B D, A P. In the triangle B A D, the sides B A, A D, are equal; therefore, the angles A B D, A D B, are equal, and are together equal to the whole acute angle A B P, or A D P, therefore the acute angle A B P is equal 180° — a the obtuse angle; hence its value is known, which we will call b.

2. *To ascertain the proportion of the diagonals* B D *to* A P.

Here we may observe, that these diagonals by their intersection at S, form four right-angled triangles, of which all the angles and the sides B A, A D, D P, P D, are known. Now take the length of the side A B at any given number, say 1000 parts, which call — m: then in the right-angled triangle B S A, all the angles and the side B A being known, therefore the sides S A, S B, are found, and these are the demi-diagonals of the rhomb, which being known, we have the proportion of the diagonals to the sides in 1000 or in any given number of parts.

3. *To determine the breadth or height* A X, A Y, *of the rhomboid, or its proportion to the sides* A B, &c.

Let X A be drawn perpendicular to A D, therefore as the angle B A D is known, and the angle X A D is a right angle, the angle B A D less 90°, will be equal to B A X; hence in the right-angled triangle B A X, the side B A, and all the angles are known, from whence we learn the value of A X or the breadth of the rhomb, and the same applies to the lines A Y, Y H, H X.

4. *To ascertain the solid angle formed by the incidence of the planes of the rhomb.*

The lines X A, A Y, being equal, and their proportion to the edges A B, A C, known, the diagonal C B, equal to Y X, being also known, if we let fall the perpendicular A Z, we shall have the right-angled triangle A Z Y, of which the angle Z, and the sides Z Y, A Y, are known; hence we learn the angle Z A Y, which is half of X A Y, that measures the incidence of the planes of the rhomboid; hence the obtuse solid angle being found, the acute solid angle A Y H is given.

5. *To ascertain the solid angle at the summit of the rhomboid formed by the edge* A D, *with the line* A K, (fig. 12.)

Let us suppose a section to be made through the larger diagonals of the rhomb B C, B D, C D; this section will cut off the three-sided pyramid (fig. 13.), having an equilateral triangle for its base, formed of the three equal larger diagonals B C, B D, C D. The angle at the summit A is that of the rhomboid, and the base is a plane perpendicular to its axis A I. To determine the measure of the angle D A N (fig. 12.), or D A N (fig. 13.), from all the angles of the equilateral triangle B C D, let the lines B G, C M, D N, be drawn to the middle of the lines B C, C D, D B, these lines will intersect each other in the centre of the triangle. Let the perpendicular A F be drawn from the summit of the pyramid to the centre of the base F. Let A N be drawn perpendicular to B C, the angle D A N will be the solid obtuse angle of the rhomboid, and the line A N half the smaller diagonal of its plane. (See fig. 12.)

To determine the measure of the angle N A D, it will be necessary to ascertain that of the two angles, into which it is divided by the line A F, and also the proportion of the two parts N F, F D, of the line N D. The angle B F D, at the centre of the equilateral triangle being twice that of C, or 120°, (Euclid, Lib. iii. Prop. 20.) and the angle D F M being half of that, or 60° ; then in the triangle D F M, all the angles and the side D M being known; hence the value of D F is found, and also of F M; but F M is equal to N F, therefore the value of the two parts N F, F D, is found.

And in the right-angled triangle D A F, knowing the right angle F, and the sides A D, D F ; hence it will be easy to discover the value of the angle D A F: this being found we have to discover the value of the remaining part of the angle or N A F; but the side A N, which is half the shorter diagonal being known, and also the side N F equal to F M being known, and the angle N F A being a right angle, the value of the angle N A F is found, which added to the angle D A F, gives the obtuse solid angle of the rhomb in its principal section, or the angle K A D (fig. 12.)

According to Bournon, this angle is the most easy to take correctly with the common goniometer, and serves to rectify the other admeasurements.

Unless the admeasurements of all the angles agree with the calculations deduced from the properties of the rhomb, we may be certain that they are not correctly taken. The section of the rhomb X A Y H perpendicular to the edges will form a rhomb (fig. 14.), the sides of which will correspond with the breadth of the rhomb, and measure the incidence of the planes, and if this be divided into smaller rhombs, by lines at equal distances parallel to the sides, we may suppose each of these rhombs to represent an integrant molecule, and by the lines 1, 2, 3, &c. we may determine what angles the decrement one, two, three, or any given number of molecules in breadth or height, would make either on the acute edge of the rhomb Y, or the obtuse edge H, the angles Y and H being known. To a scale of this kind, we may apply a protractor, and it will thence be easy to ascertain very nearly, what angle would be formed by a decrement of any given number of ranges, on the edge of a given rhomboid, such as the carbonate of lime, we may thus discover by what decrements certain secondary crystals are formed, and afterwards prove by calculation the correctness of the measurement.

If we suppose a section through the rhomboid along the diagonal K A and the edge A D, and also through the edge K I, and a diagonal from I to D, the section will form a lengthened rhomboid (fig. 15.), of which the angle A corresponds to A, and the sides A K, K I, I D, D A, to the same line in fig. 12. and the angle K A D is the solid angle of the summit of the rhomb, the short diagonal A I corresponds to the axis of the rhomboid A I (fig. 12.), the angle A and I forming the two solid angles at the opposite summits of the rhomboid. The distance A F (fig. 15.), which is the same as that of A F of the pyramid cut off (fig. 13.), is one-third of the length of the axis A I; for let G K, D S, be drawn from the angles K and D, to the middle of the lines A D, K I, and if we draw the lines A H, I O, (fig. 15.) parallel to the lines G K, D S; then, because K I and

A D are parallel, and equally divided by A G, G D, K S, S I, the four parallel lines H A, K G, S D, I O, will be at equal distances, and consequently the line A I is divided into three equal parts, of which A F measures the height of the pyramid, or A F, fig. 13.

In fig. 16. the principal section of the rhomb is divided into a number of smaller rhombs, each of which may represent sections of as many molecules. Now it has been shown (page 111.), that a decrement of two ranges in breadth on the angles, corresponds to one diagonal of a molecule. Now, if we suppose the *k a*, *i d*, to represent the principal section of the rhomb, and *e f* a range of molecules decreasing by one entire diagonal at the angle D, the new face formed will correspond with the line 1, 1, which is parallel to the axis of the rhomb A D. By such a scale we may approximate to the measure of all possible decrements on the angle of the rhomb.

To apply the above rules to discover the law of decrement from the measurement of a secondary crystal:—Let Plate I. fig. 9. represent an hexagonal prism of carbonate of lime terminated by three planes at each extremity. By measuring the incidence of each terminal plane, as *a. b.* on each other, we discover the angles to be 105°, which corresponds very nearly with the obtuse angles of the primitive rhomboid; hence these planes are the faces corresponding with those of the primitive crystals. Apply the arms of the goniometer to one of the faces as *c*, and to the side of the prism, placing the arms at right angles to the edge I O, or in the direction *c x x*, the angle formed will be $127\frac{1}{2}$°. Now as the edge I O corresponds with the edge of the acute angle of the primitive rhomboid, the measure of which is 75°, I learn that an addition is made to it of 52°, which is equal to the angle of a decrement of one molecule in breadth. For let the lines AB, fig. 18. represent a section of the primitive rhomboid on its acute edge, and *a* the first lamina forming a decrement of one in breadth, then the distance of the molecule *a* from the edge *c* is equal to one breadth of the molecule, and its acute edge forms with the edge C an angle which is equal to half the obtuse angle of the molecule; but as the obtuse angle of the molecule is the same as the obtuse angle of the rhomb or 105°, the half, or 52½°, is the measuring angle of a decrement of one in breadth on the acute edge, which added to 75° gives 127½°, or the angle formed by the sides of the prism with the terminal planes.

In the measurement of crystals, however, we have frequently to calculate the laws of decrement from the incidence of two faces, both of which are secondary.

Sometimes two secondary faces coincide or form together one new face. This will be the case with parallelopipeds wherever the decrement in breadth on one side is equal to the decrement in height on the other, as in the dodecahedron with pentagonal faces (Plate II. fig. 5.) Where the primitive form is a cube, or a rhomboid, decrements of one in breadth, on the two sides of the same edge, form new faces which coincide, or, in other words, form together one new face. Let A D, D B, fig. 17. represent the section of the primitive nucleus, and *a* and *b* decrements of one in breadth on each side of the edge D, the new faces will be formed by the edges of *a* and *b*; but the sides of the molecules *a d*, *b d*, are parallel to each other, and to the side of the primitive crystal D *d*, and the angle D *b* B, formed by the decrement on that side of the crystal, is equal to the angle *a* D A, formed by the decrement on the other side, the two sides and inner angles being equal; therefore the lines *a* D, D *b*, form equal angles with two parallel lines *d* D, *d b*, and meet at the point D. But two lines that form equal angles with two parallel lines and meet at the same point, are both in the same plane, or form one right line; therefore the two faces D *a*, D *b*, on each side of the edge D, form one plane or one new face of the secondary crystal. It would be easy to demonstrate the same in all cases where the decrement in height on one side of an edge contains the same number of ranges as the decrement in breadth on the other. The above simple cases may suffice to explain the principles on which the application of geometry to crystallography are founded.

ADDENDA, No. III.

DOUBLE MAGNETISM.

The magnetic needle when at rest is retained in its situation by the magnetism of the earth, which is sufficiently powerful to prevent the needle being affected by minute portions of iron in certain minerals. In order to diminish the force of the earth's magnetic attraction, let a magnet be placed on the same level with the needle, and in a direct line with it, but having its poles reversed, or the south pole pointed towards the north pole of the earth. Let the magnet be gradually moved nearer to the needle, and at a certain distance the needle will begin to move round and oscillate, and if the distance be properly adjusted it will point east and west; then let the magnet remain stationary. The polar attraction of the needle is now in equilibrio, being divided between the magnet and the earth. In this situation a very minute portion of iron in a mineral will sensibly affect the needle, if brought near one of its poles. The Abbé Haüy, who invented this method of rendering the magnetic attraction of certain minerals sensible, says, that even the minute portion of iron contained in the precious garnet will affect the needle by this mode, which I have frequently verified.

[illegible]

[illegible]

[illegible]

INDEX

TO

THE NAMES OF MINERALS,

AND TO

THE TERMS

EMPLOYED IN

MINERALOGY AND CRYSTALLOGRAPHY.

THE names of the varieties being enumerated at the head of the description of each species of Earthy Minerals in Book II., and the names of the species and varieties at the head of each genus of Metallic Minerals in Book III., it has not been deemed necessary to introduce them all in the Index, unless they have a distinct name: — thus, Compact Felspar will be found by referring to Felspar, Book II.; but Adularia being a distinct name is inserted in the Index: Ruby-Silver will be found under Genus Silver, Book III. &c.

THE END.

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EXPLANATION OF THE CRYSTALS

REPRESENTED IN PLATES III. IV. AND V.

PLATE III.

Boracite, fig. 9.
Sulphate of Lime, 10, 11, 12.
Calcareous Spar, 13 to 22, and 3 to 8.
Sulphate of Barytes, 23, 24, 25, 26.
Sulphate of Strontian, 27, 28.
Zircon and Hyacinth, 29, 30, 31.
Quartz, 32, 33.
Felspar, 34, 35, 36, 37, 38, and fig. 2.
Topaz, 39, 40, 41.

PLATE IV.

Stilbite, 1, 2.
Analcime, 3.
Chabasie, 4.
Cross-Stone, 5.
Axinite, 6, 7.
Idocrase, or Vesuvian, 8.
Garnet, 9, 10.
Tourmaline, 11, 12, 13.
Epidote, 14, 15, 16.
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Chrysolite, or Peridot, 20.
Augit, or Pyroxene, 21, 22.
Amphibole, or Hornblende, 23, 24, 25.
Chiastolite, or Hollow-Spar, 26.
Grenatite, or Staurotide, 27, 28.
Spheroidal Diamond, 29.
Sulphur, 30, 31.
Sulphuret of Arsenic, 32.
Wolfram, 33, 34.
Geniculated Titanite, 35.
Sphene, 36, 37.
Anatase, 38.
Manganese, 39.
Sulphuret of Antimony, 40.

PLATE V.

Cobalt, Arsenical, 1, 2. 6.
Calamine, Electric, 3.
Blende, 4.
Arsenical Iron, 5.
Iron Pyrites, 6 to 11.
Iron Glance, or Fer Oligiste, 12, 13, 14.
Sulphate of Iron, 15.
Tin, 16, 17, 18.
Carbonate of Lead, 19.
Sulphate of Lead, 20.
Molybdate of Lead, 21, 22.
Grey Copper, 23, 24.
Blue Carbonate of Copper, 25.
Sulphate of Copper, 26, 27.
Argentiferous Mercury, 28.
Cinnabar, 29.
Red Silver, 30, 31, 32.

ERRATA ET CORRIGENDA.

Page 66. line 9. *for* “ is one form,” *read* “ are certain forms.”
—— 115. line 2. from bottom, *dele* “ the” before faces.
—— 117. line 13. *for* “ rhomboids,” *read* “ rhomboidal prisms.”
———— line 17. *for* “ three,” *read* “ these.”
—— 136. line 6. from bottom, after “ from,” *read* “ a decrement of.”
—— 146. bottom line, *for* “ Plate V.” *read* “ Plate IV.”
—— 151. *for* “ Plate V. fig. 7.” *read* “ fig. 11.”
—— 162. *for* “ Plate III. fig. 39.” *read* “ fig. 38.”
—— 177. *for* “ Platina 25,” *read* “ 21.41.”
—— 186. line 9. from bottom, *dele* the “ semicolon” after minerals.
—— 207. *for* “ Euclare,” *read* “ Euclase.”
—— 245. line 9. *read* “ it is slightly translucent and has a.”
—— 281. line 9. from bottom, *read* “ designating a species.”
—— 291. *for* “ Plate IV. fig. 28.” *read* “ fig. 26.”
—— 303. *for* “ Plate IV. fig. 9.” *read* “ fig. 21.”
—— 365. *for* “ Plate IV. fig. 6.” *read* “ fig. 8.”
—— 372. *for* “ Plate III. figs. 30, 31.” *read* “ Plate IV. figs. 18, 19.”
—— 393. line 4. from bottom, *dele* “ double” before refraction.
—— 396. line 15. *for* “ Staurotide,” *read* “ Sappare.”
—— 445. line 6. *for* “ coloured,” *read* “ changed to red.”
—— 507. top line, *read* “ soil; in the year 1810, 1514 ounces were “ obtained, one mass weighing 28 lbs.”
—— 621. line 2. from bottom, *for* “ connoisseurs,” *read* “ connoissances.”
—— 651. line 13. from bottom, *for* “ rhomboid,” *read* “ rhomboidal “ plane.”

PLATE I.

Fig. 12.

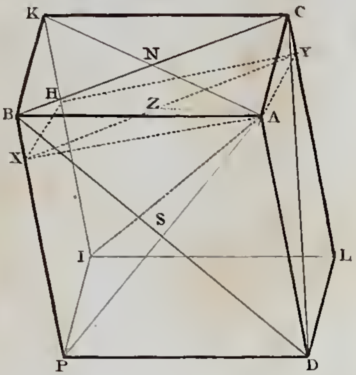


Fig. 9.

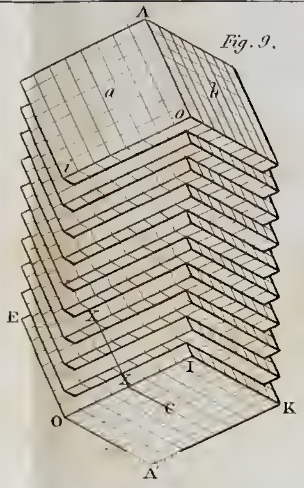


Fig. 10.

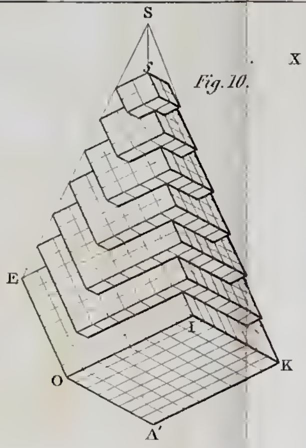


Fig. 14.

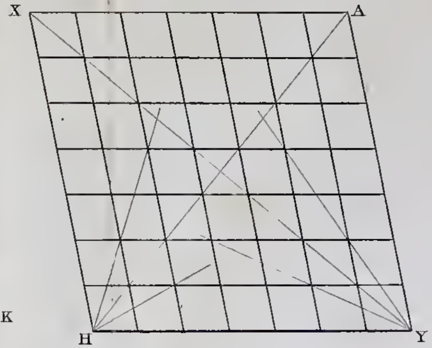


Fig. 13.

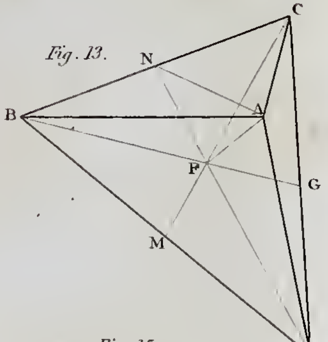


Fig. 3.

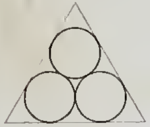


Fig. 4.

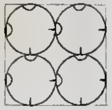
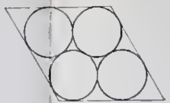


Fig. 5.



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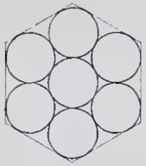

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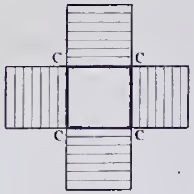

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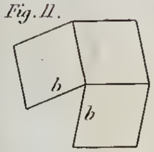

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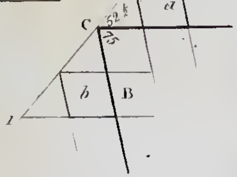

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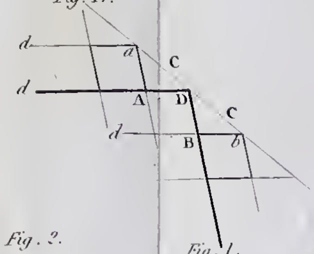

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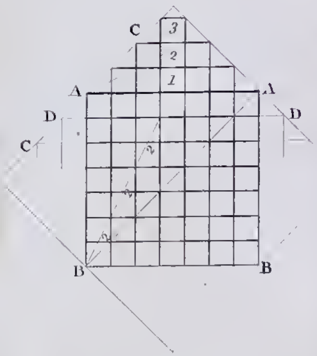

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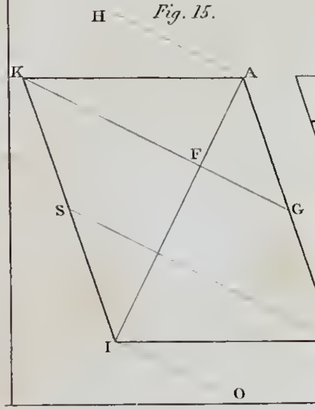

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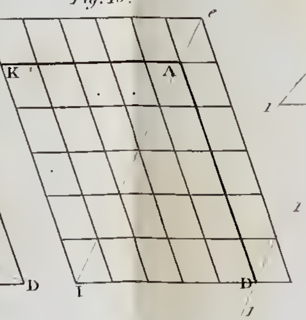

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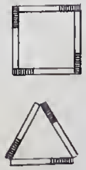
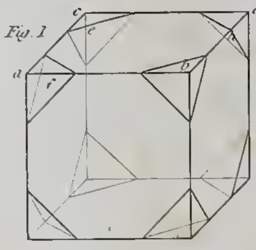


Fig. 1.

PLATE II.

Fig. 1.



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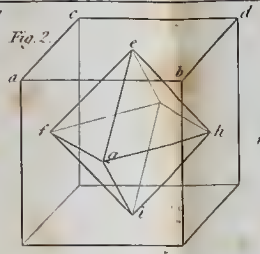

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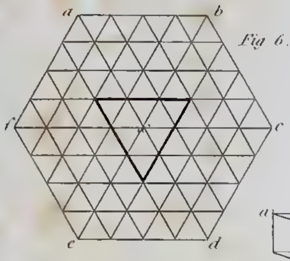

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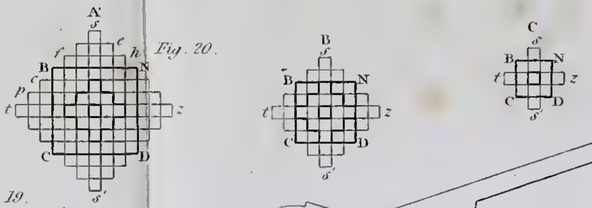

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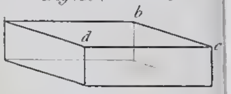

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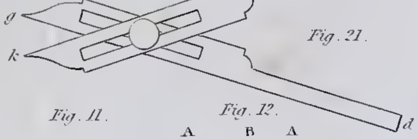

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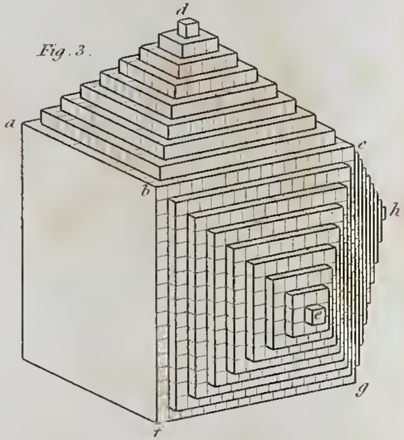

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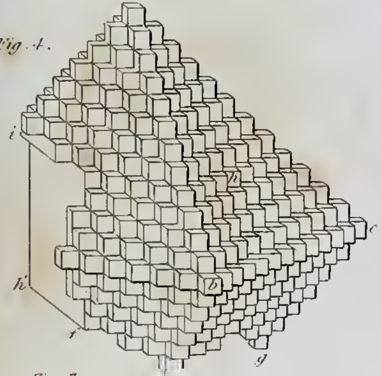

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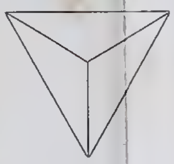

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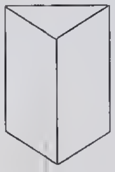

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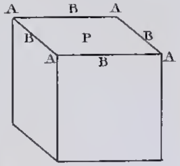

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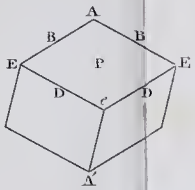

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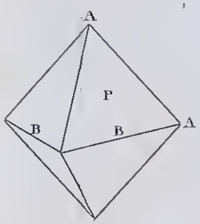

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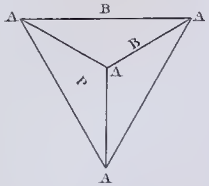

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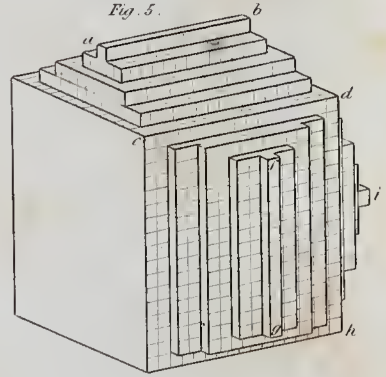

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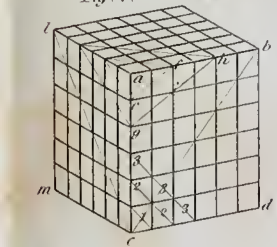

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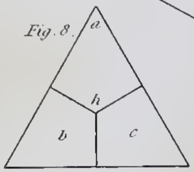

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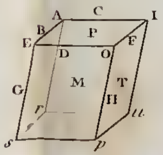

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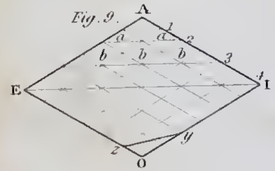

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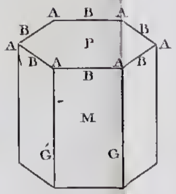

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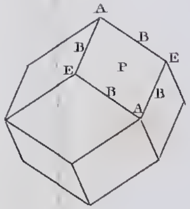

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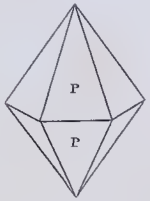

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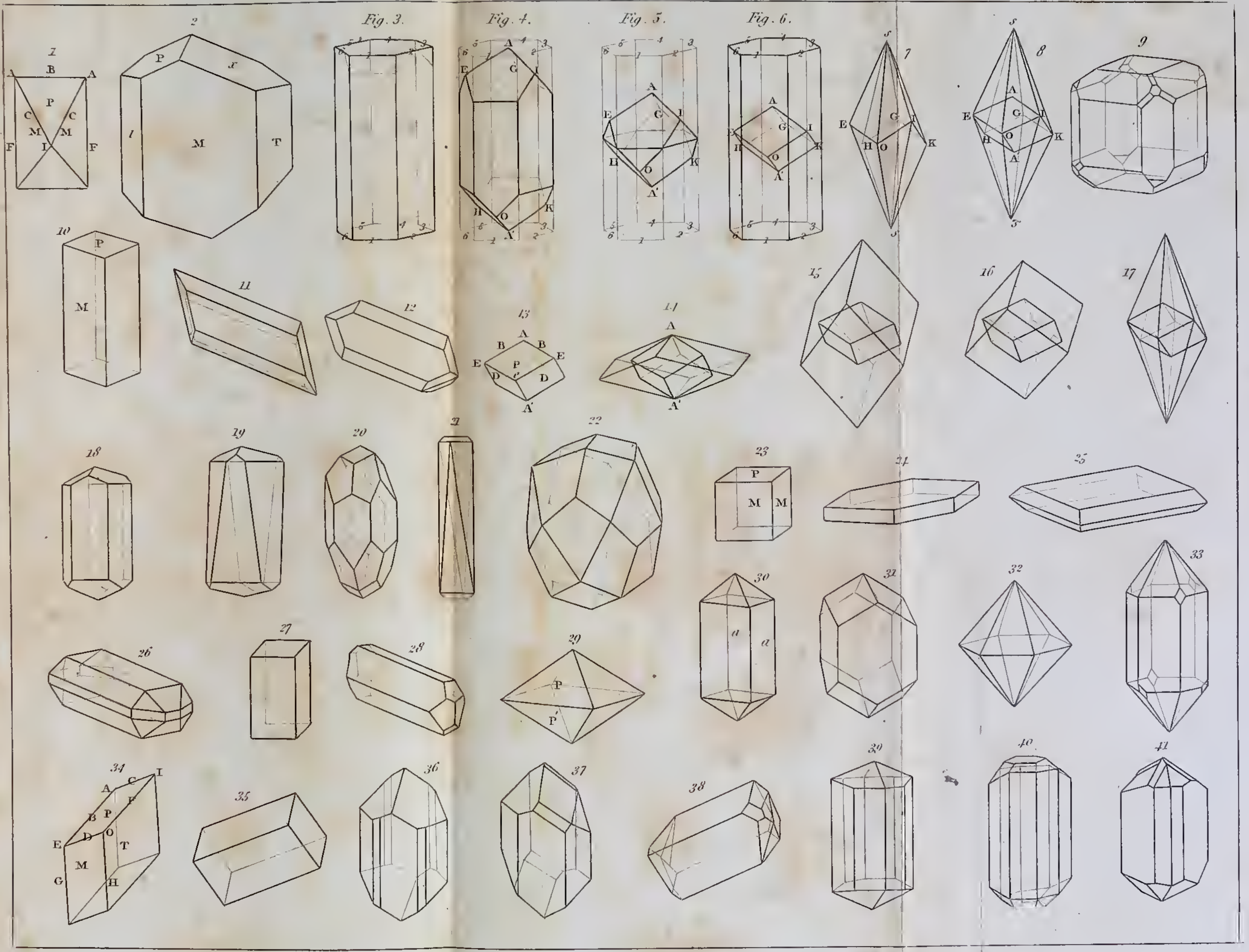
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PLATE . IV.

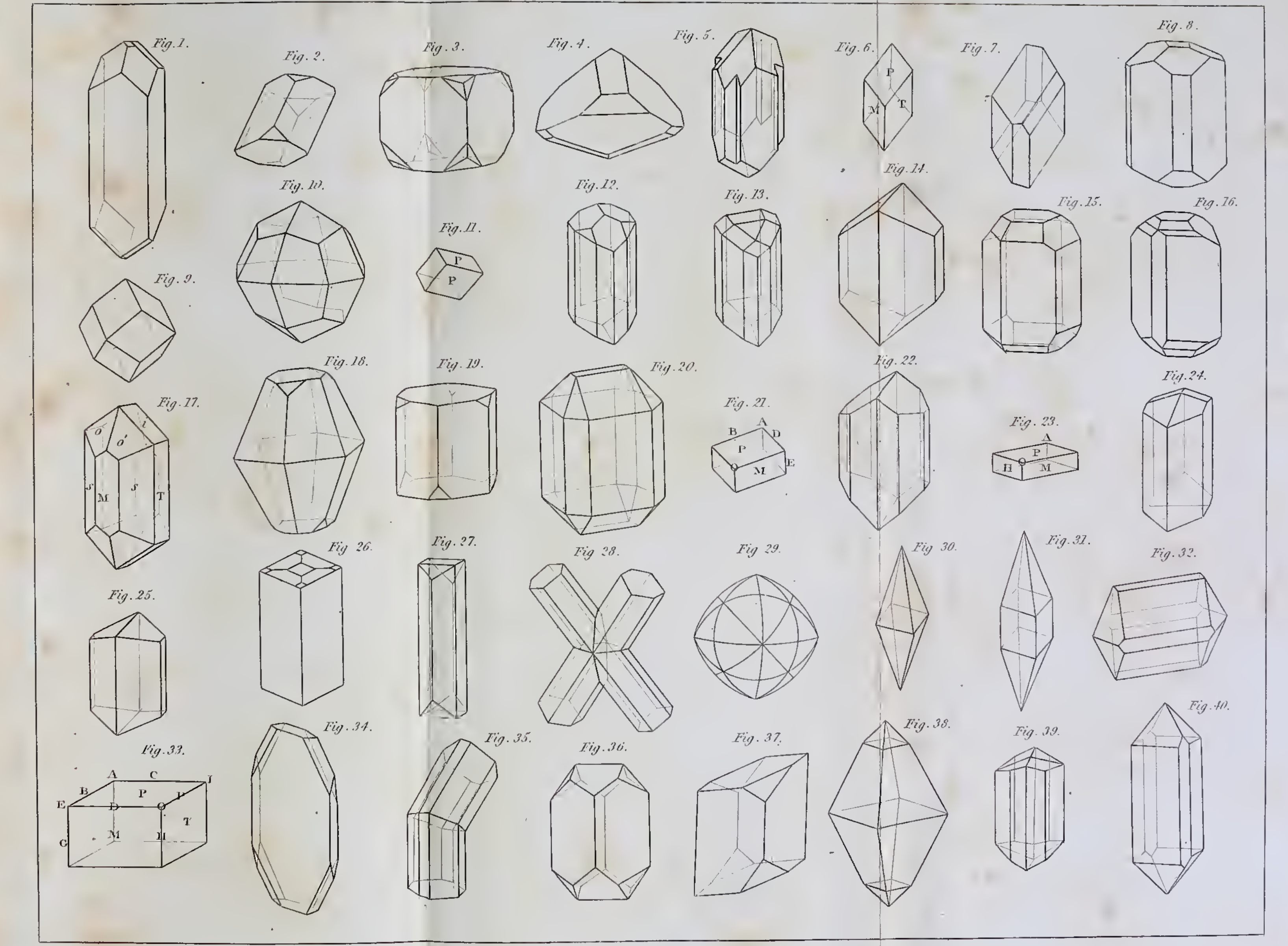
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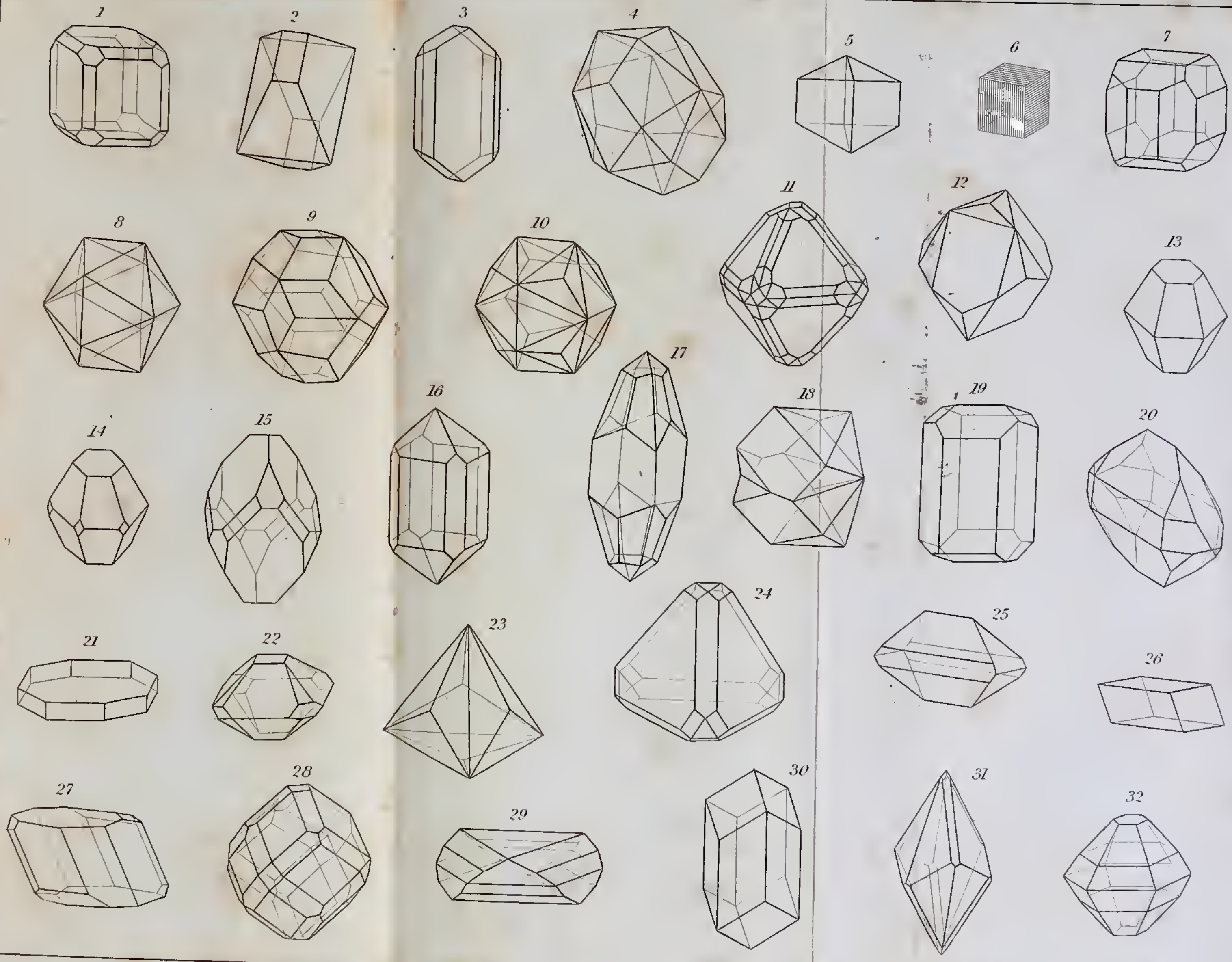
Plate V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